

SPARROW Surface Water Quality Workshop

October 29-31, 2002

Reston, Virginia

Section 5. SPARROW Stream Network Infrastructure and GIS Techniques

SPARROW

Stream Network Infrastructure

- SPARROW Network, what is it and how is it used.....
 - Components and Function
 - Properties
 - Construction
- Approaches to different network developments
 - ❖ National Applications Using ERF1 - Jacquie
 - ❖ Chesapeake Bay Applications using ERF1 and DEM - John
 - ❖ New England Applications using NHD – Richard/Craig
- SPARROW data sources
 - Nutrient source data sets
 - Delivery data sets
- Data types and aggregation
- Data Management

SPARROW Data Components

- Network
 - Stream Reaches
 - Associated Watersheds
- Dependent Variable
 - Stream Loading Information
- Nutrient Source Information
- Land to Water Delivery Factors

GIS Arc/Info & ArcView

SPARROW

SAS & Fortran

Nutrient
Sources

Delivery

Network
Based on Stream Reaches
and Watersheds

Modeling
Process

Estimated Loads by Stream Reach
Incremental, Delivered, and Total

Predictions and
Diagnostics

All
Sources

Land Use

Fertilizer

Point
Source

Atmospheric
Deposition

Manure

Network Functions

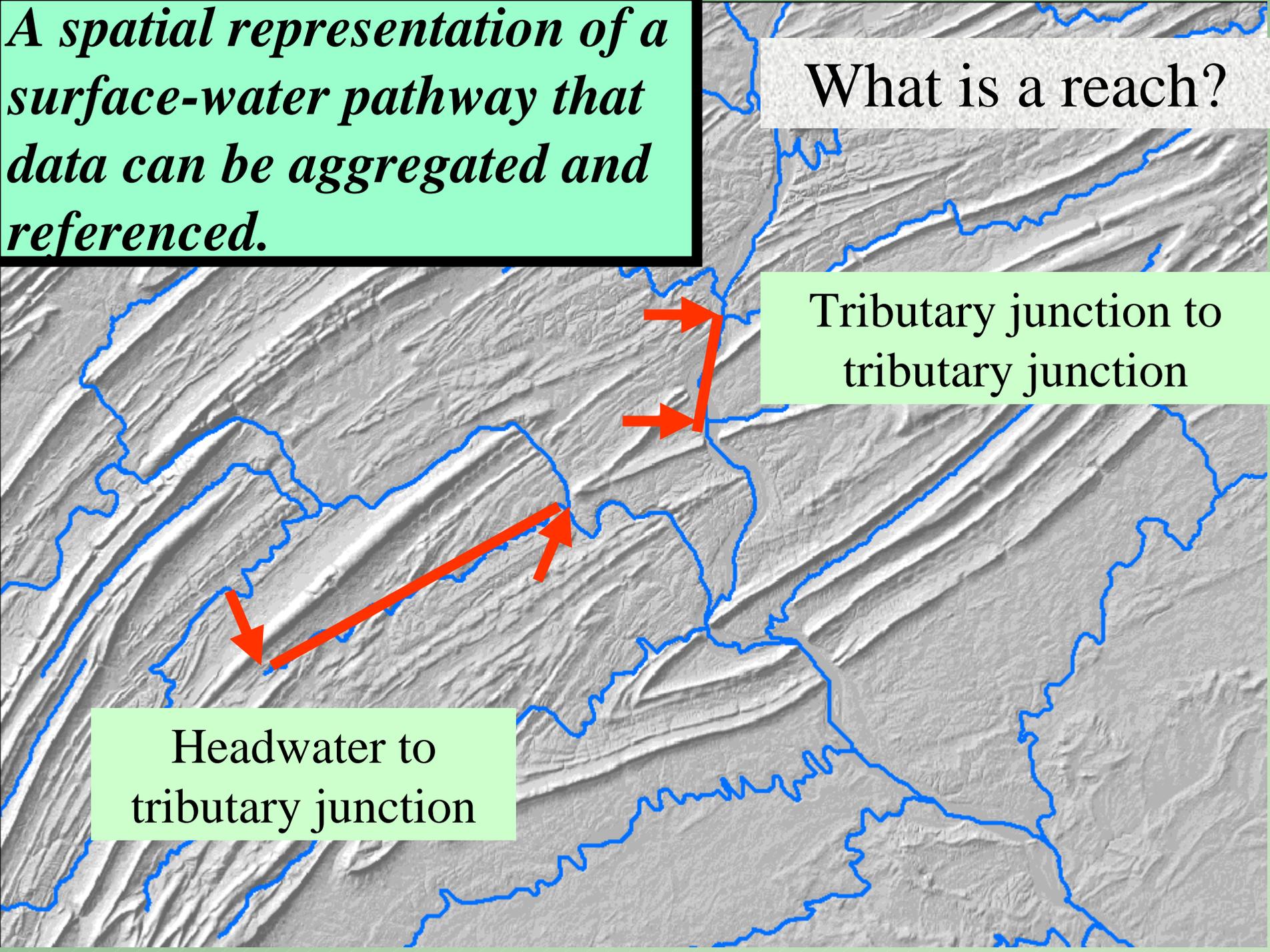
- *Provides the framework to spatially reference data used as input to the SPARROW models*
 - stream load data (Dependent)
 - nutrient source data
 - delivery data

A spatial representation of a surface-water pathway that data can be aggregated and referenced.

What is a reach?

Tributary junction to tributary junction

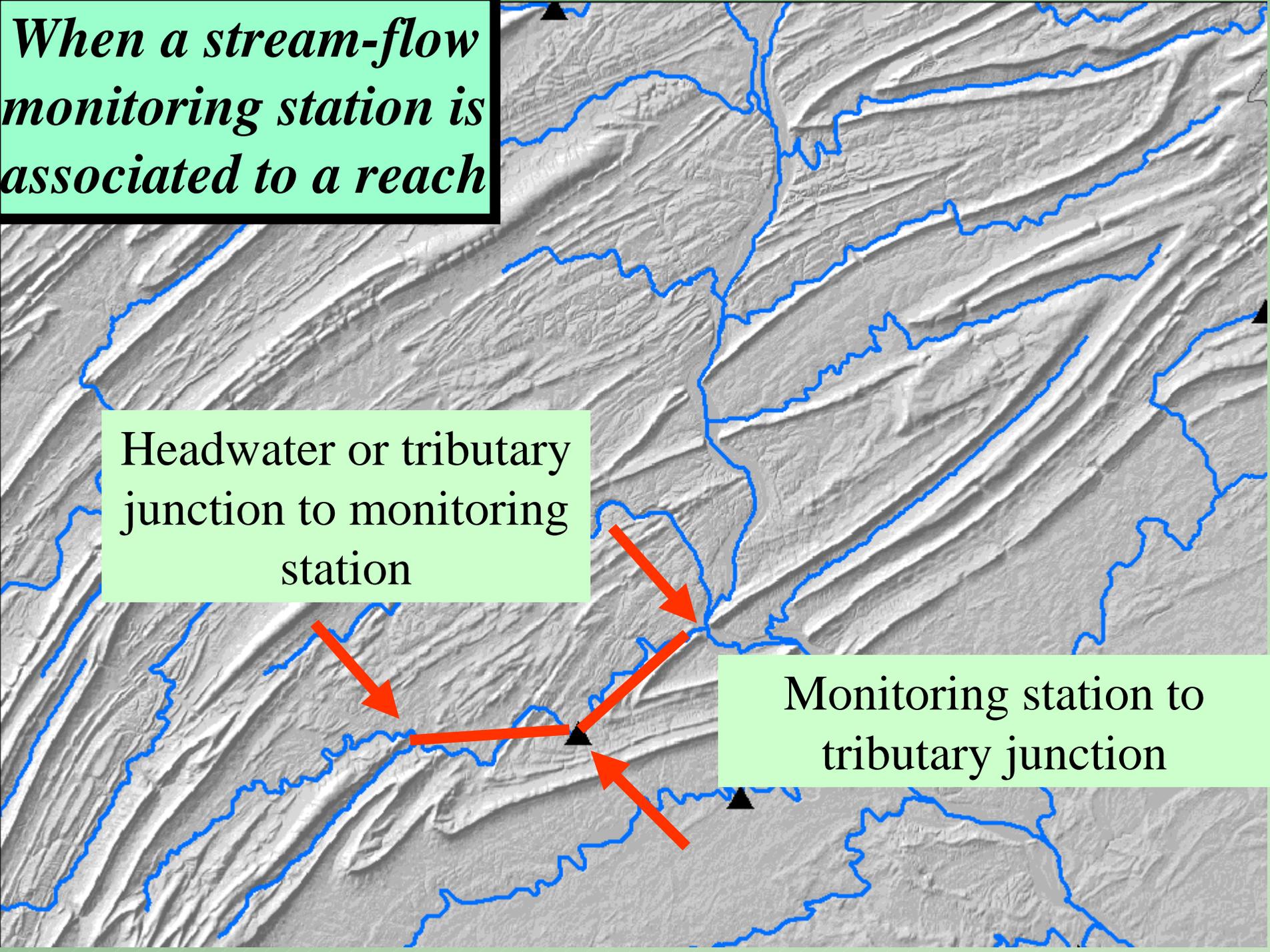
Headwater to tributary junction



When a stream-flow monitoring station is associated to a reach

Headwater or tributary junction to monitoring station

Monitoring station to tributary junction



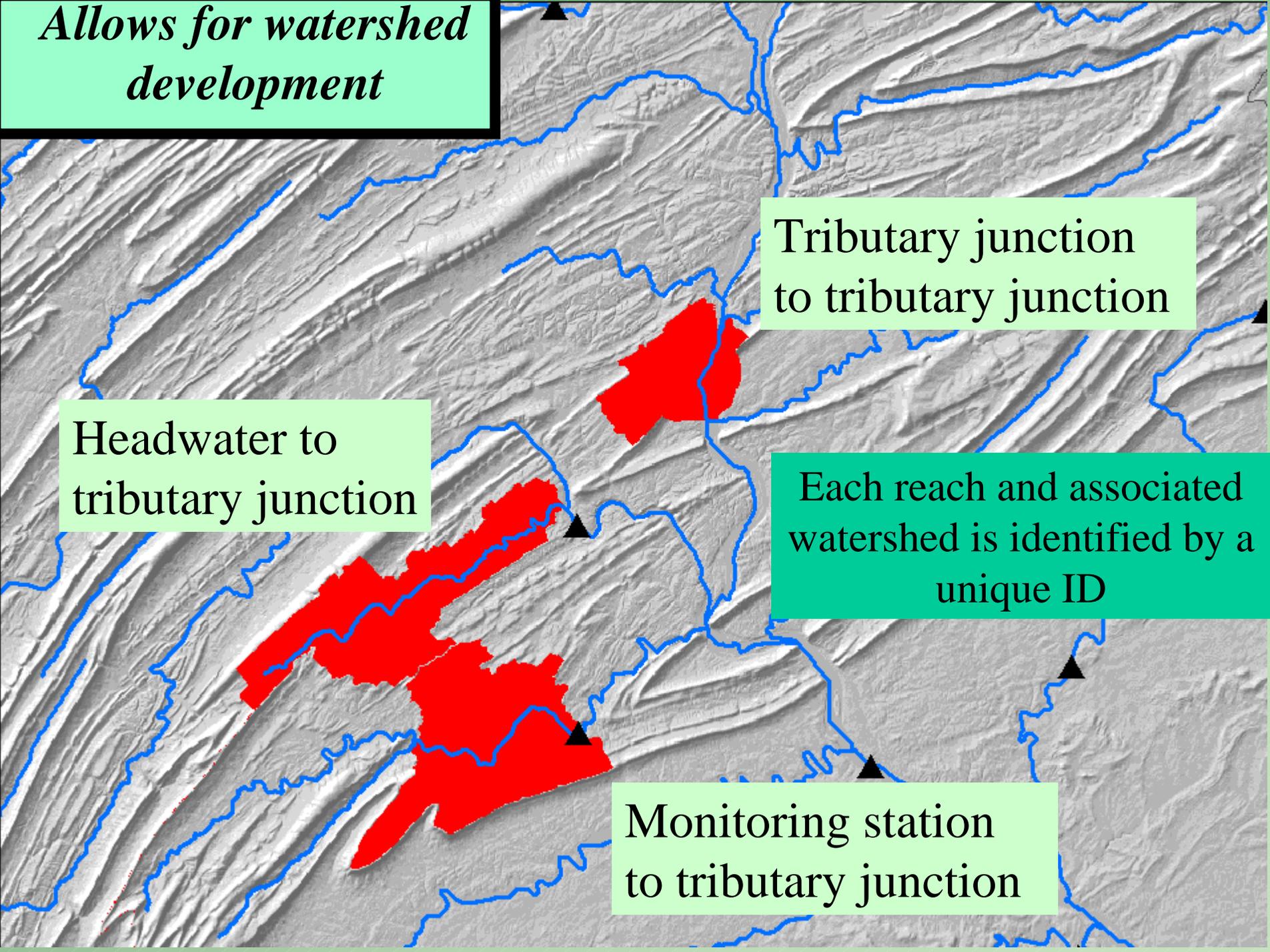
Allows for watershed development

Tributary junction
to tributary junction

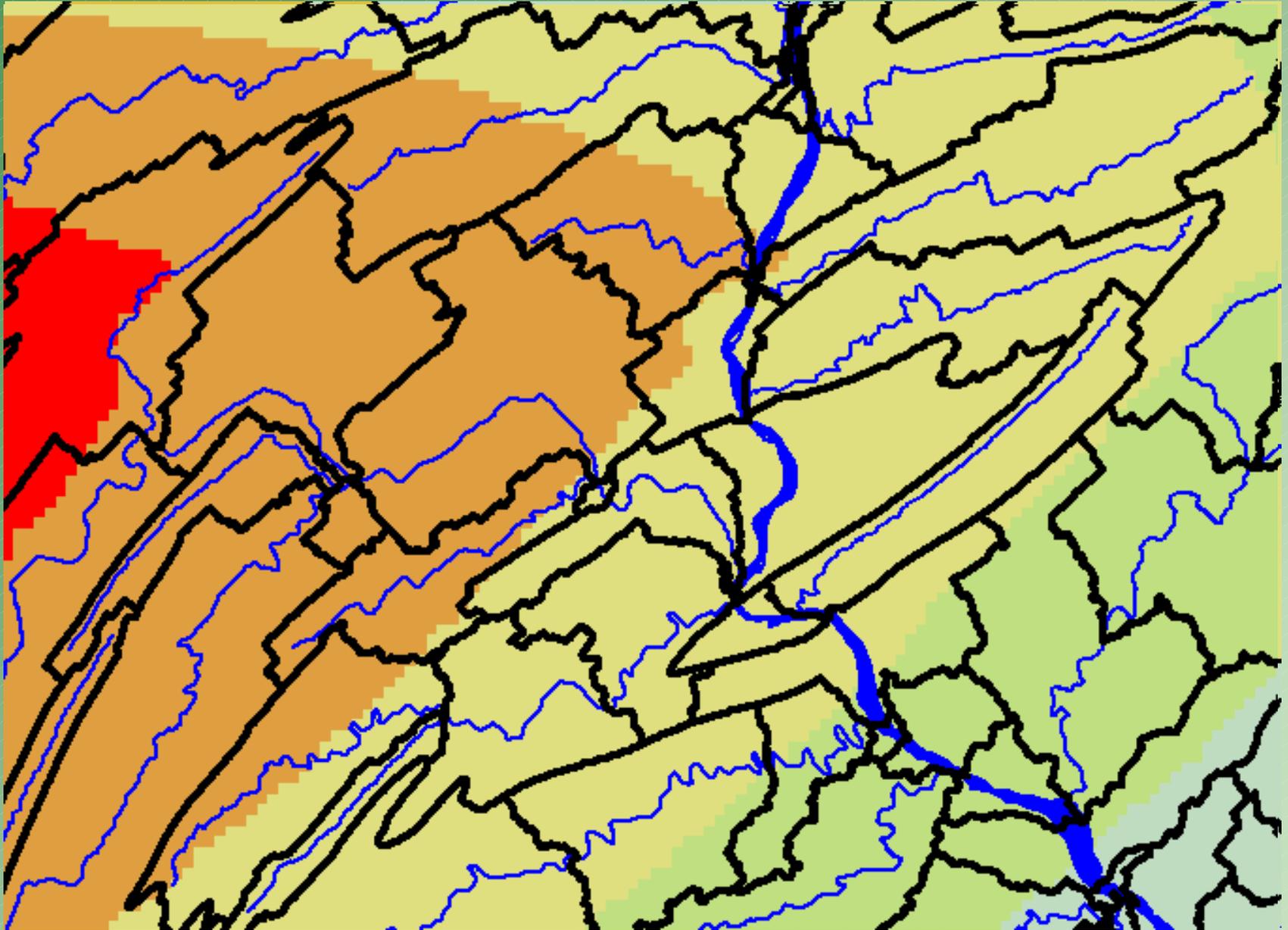
Headwater to
tributary junction

Each reach and associated
watershed is identified by a
unique ID

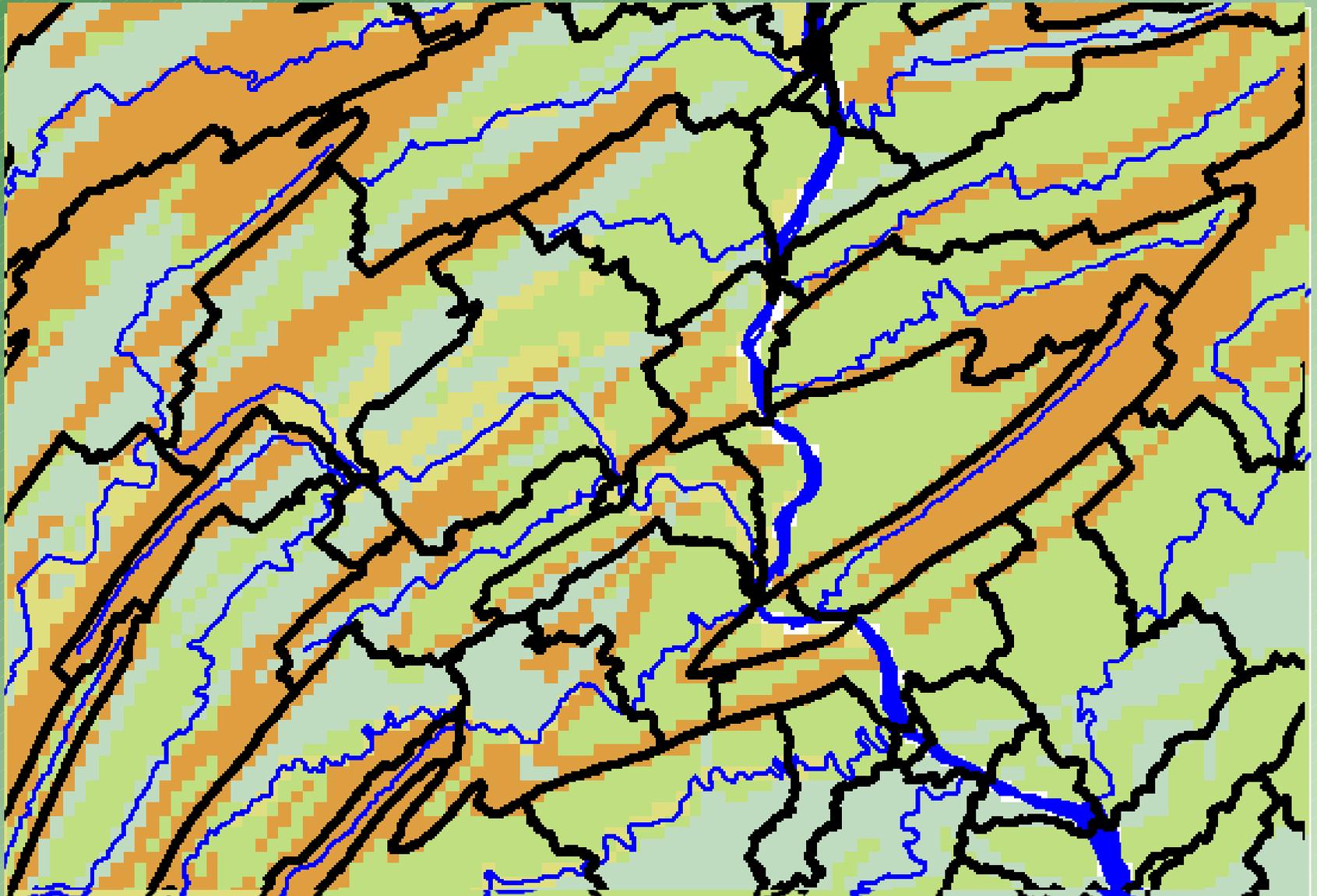
Monitoring station
to tributary junction



Referencing nutrient source data - Atmospheric Deposition



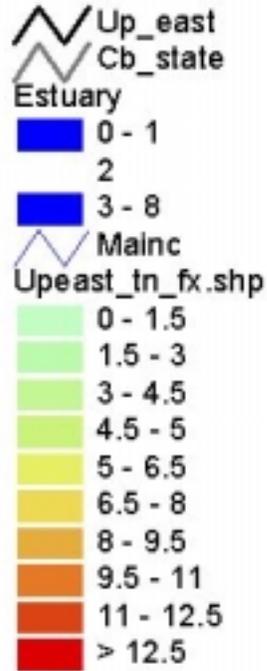
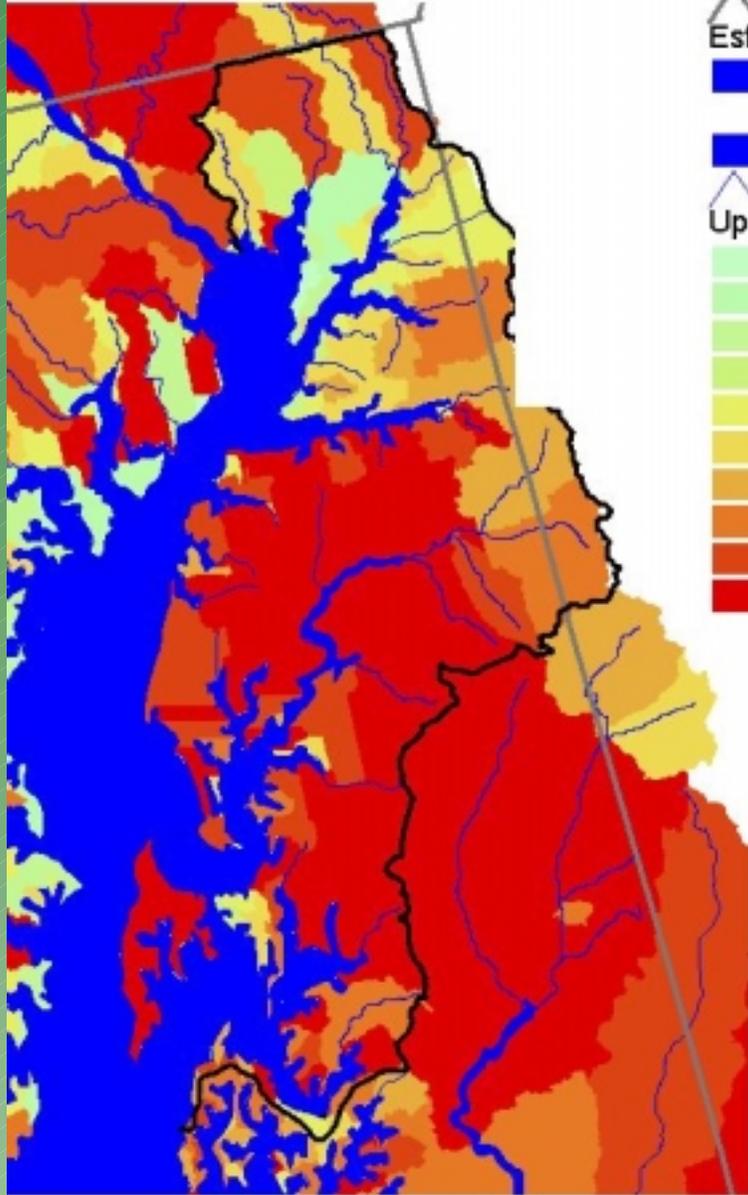
Referencing delivery data - Soil Permeability



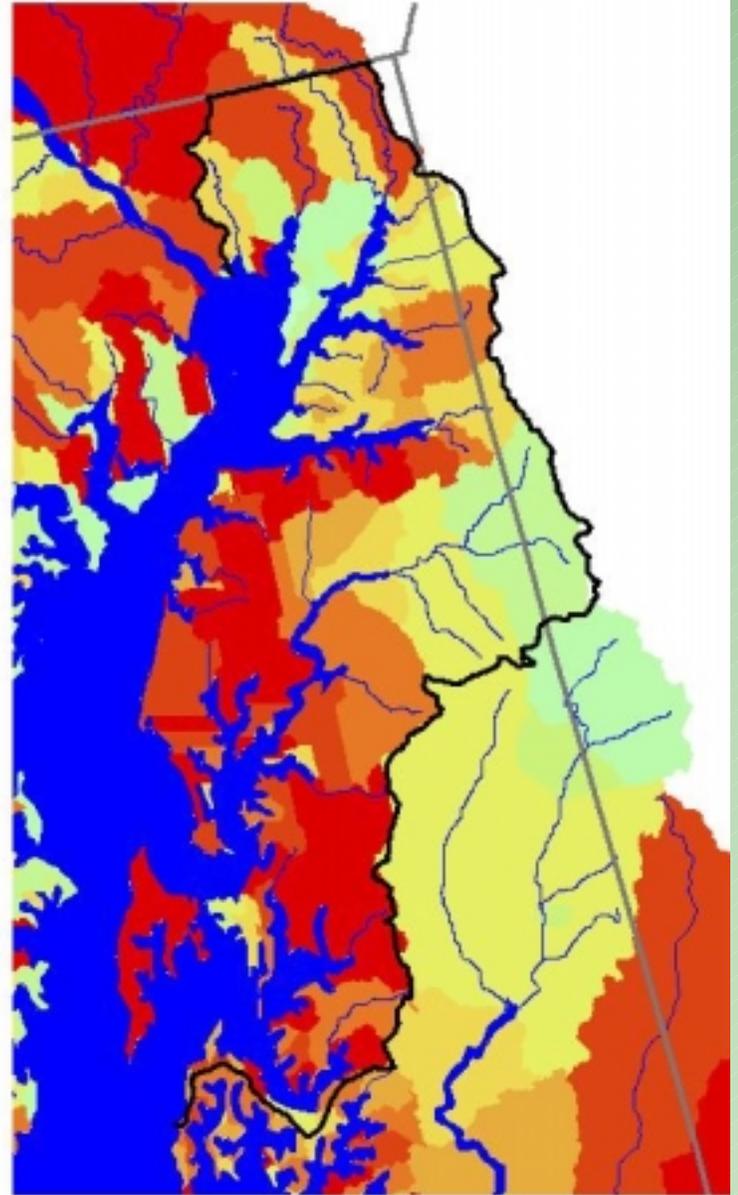
Network Functions

- *Used to illustrate the spatial distribution of predicted nutrient yields and their potential for delivery (Model Output).*

TN Incremental Yield All Sources kg/ha/yr

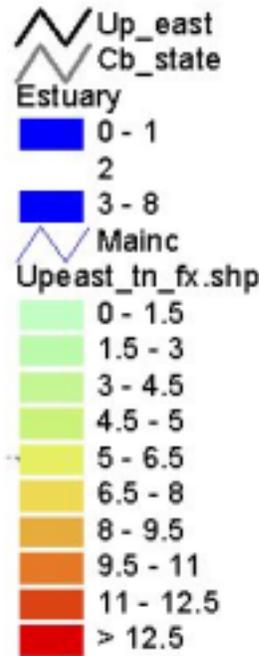
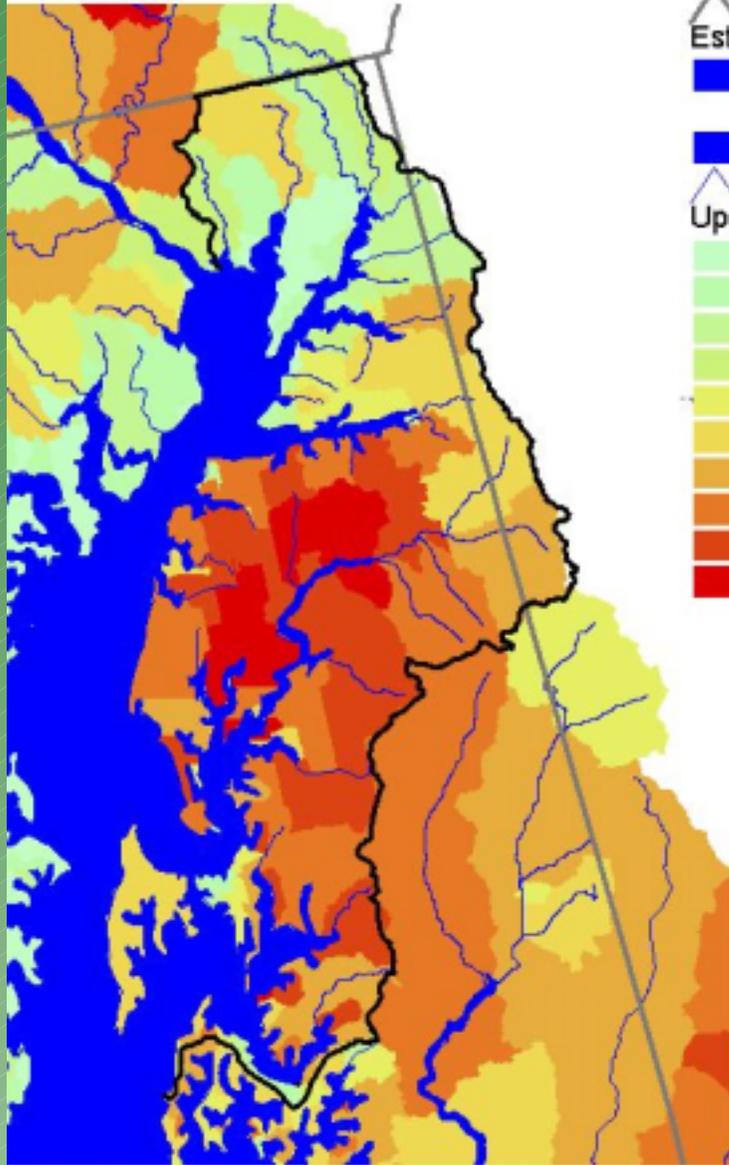


TN Delivered Yield All Sources kg/ha/yr

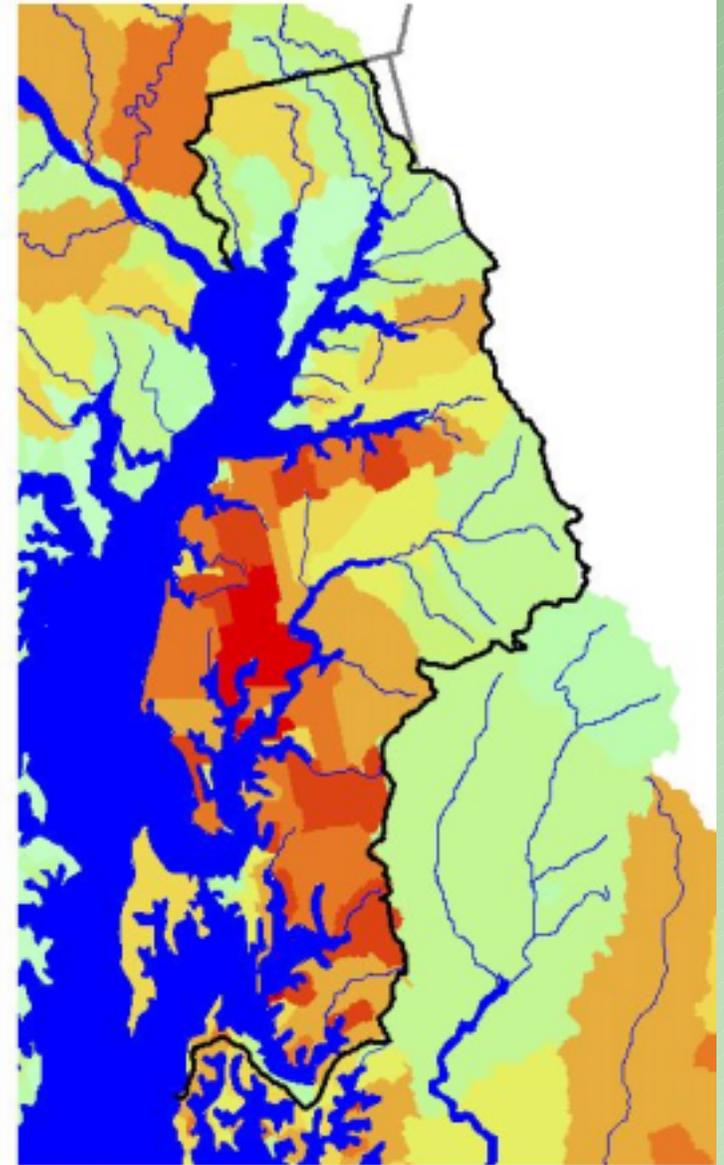


SPARROW Estimates of Total Nitrogen for all Sources, 1992

TN Incremental Yield Fertilizer kg/ha/yr



TN Delivered Yield Fertilizer kg/ha/yr



SPARROW Incremental and Delivered Estimates of Total Nitrogen
from Fertilizer Sources, 1992

Network Components

1) Annual Stream-Loading Data

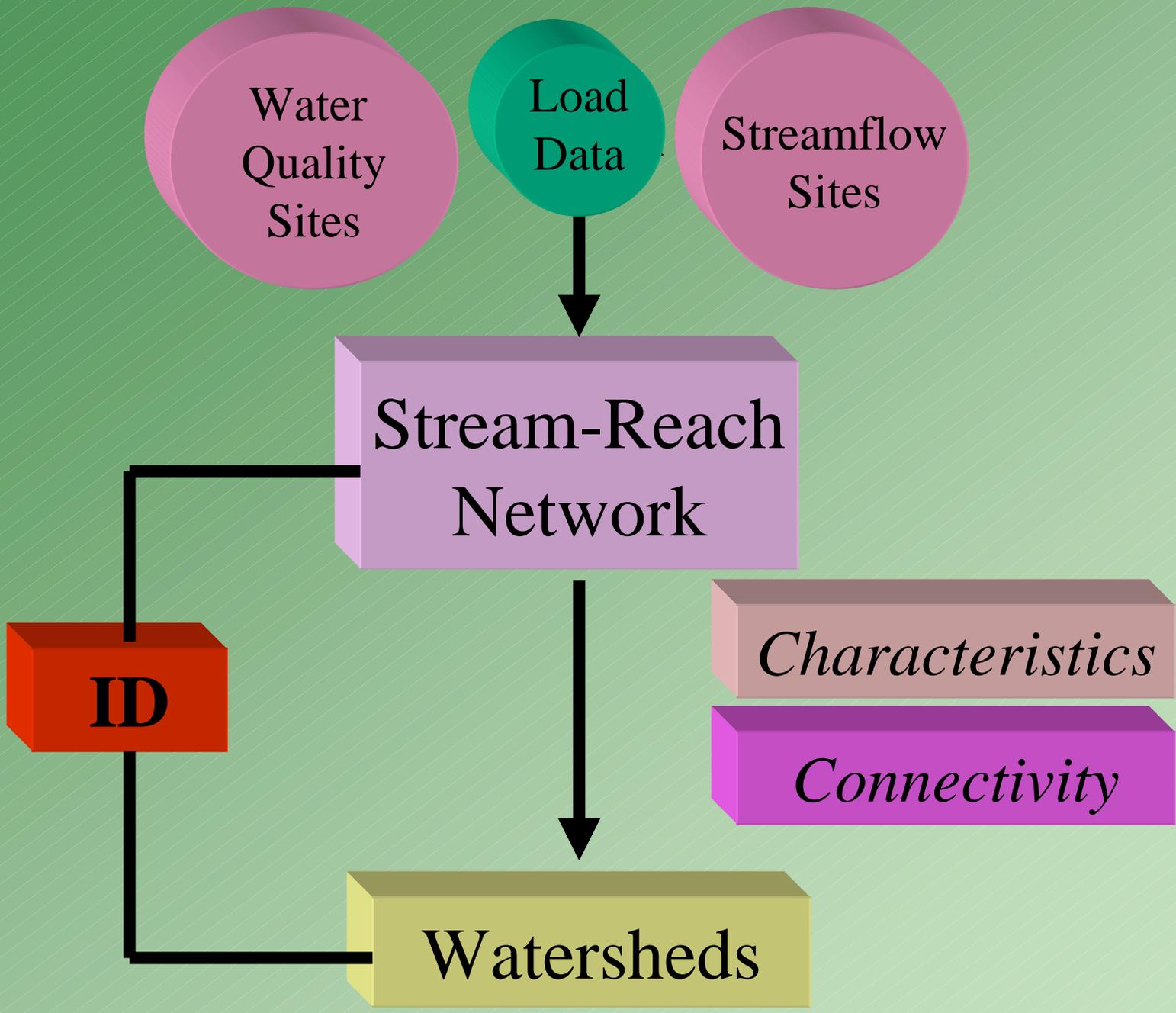
- Necessary streamflow and water quality
- Located on digital stream reach

2) Digital Stream Reaches (linear representation)

- Based on Stream Reach Files
 - RF1 Based
 - DEM Derived
 - NHD
 - o 1:100,000
 - o 1:24,000

3) Watersheds for Each Reach (area representation)

- Digital Elevation Models
- Existing watershed boundaries



Water
Quality
Sites

Load
Data

Streamflow
Sites

Stream-Reach
Network

ID

Characteristics

Connectivity

Watersheds

Watersheds

Land Use

Manure

Soil

Climate

Fertilizer

Nutrient Sources

Atmospheric Deposition

Slope

Delivery

Geology

Point Sources

Spatially referenced

Density

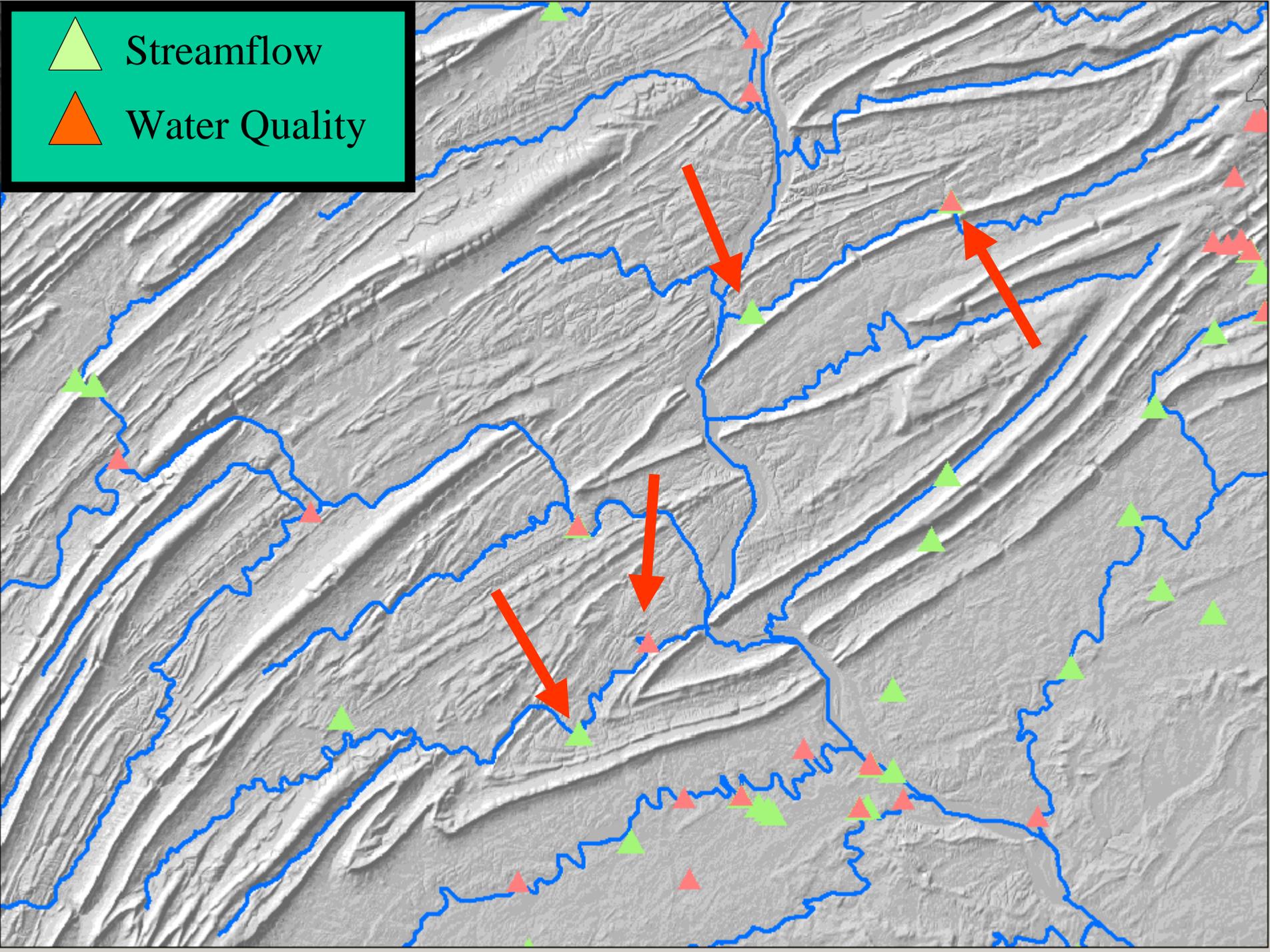
ID and Value

Modeling Process

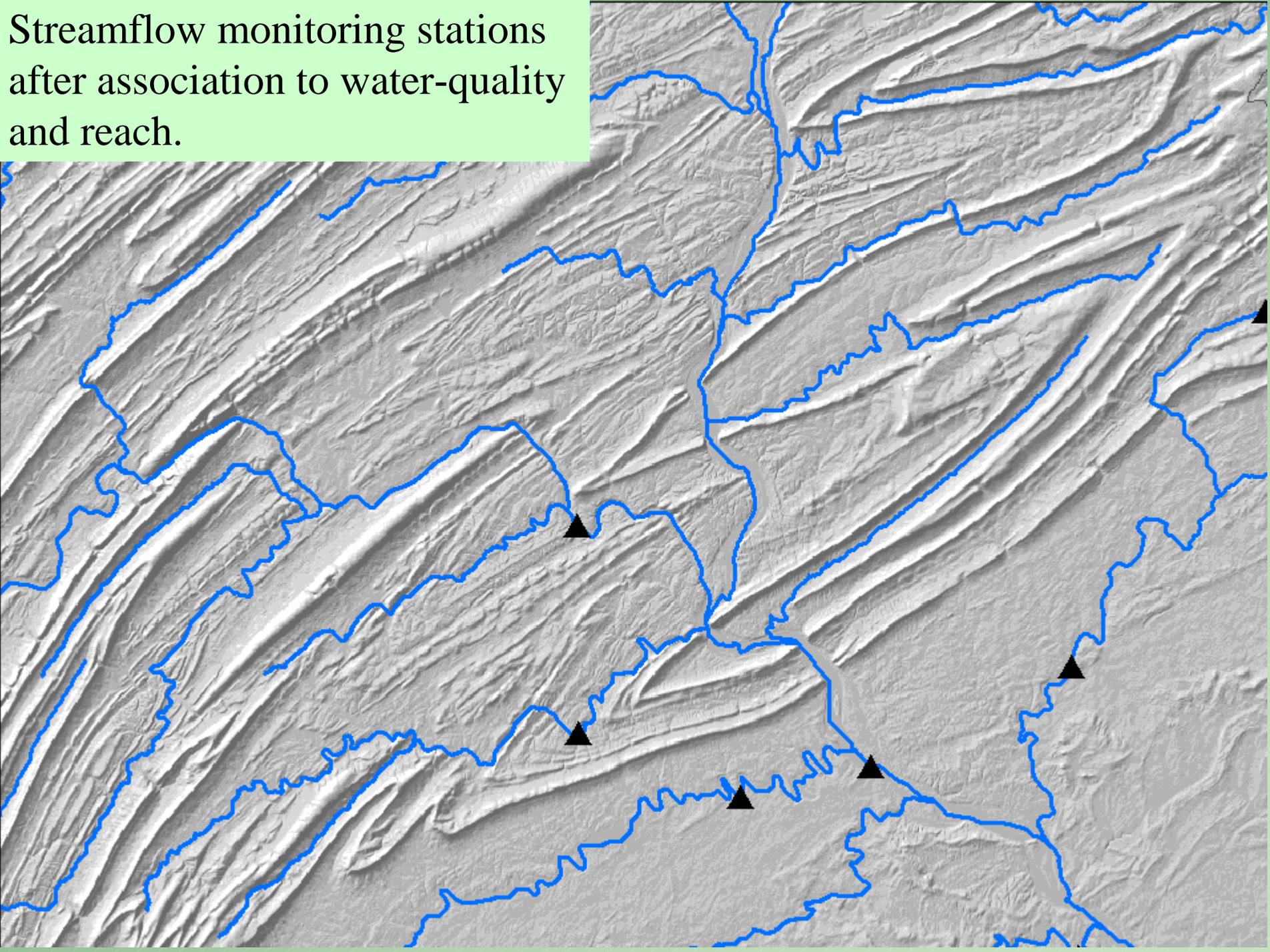
Network Properties

Annual Stream-Loading Data

- Location considerations (Accuracy and on reach)
 - Annual Data Reports
 - NWIS Web
- Contaminate sampled
- Period of Record
 - Streamflow
 - QW
- Streamflow and Water-Quality sampling site association
- Reach association



Streamflow monitoring stations
after association to water-quality
and reach.



Network Properties

Digital Stream Reaches

- Single pathway representing surface-water
- Connectivity and Orientation
- Topologically Consistent (Node topology and direction, and flow tables)
- Referenced Monitoring Stations
- Referenced Reservoir Information
- Attributes of Stream Characteristics
 - Time of Travel (Length / Velocity)
 - Streamflow

Network Properties
Digital Stream Reaches

Watersheds
generated for each
reach

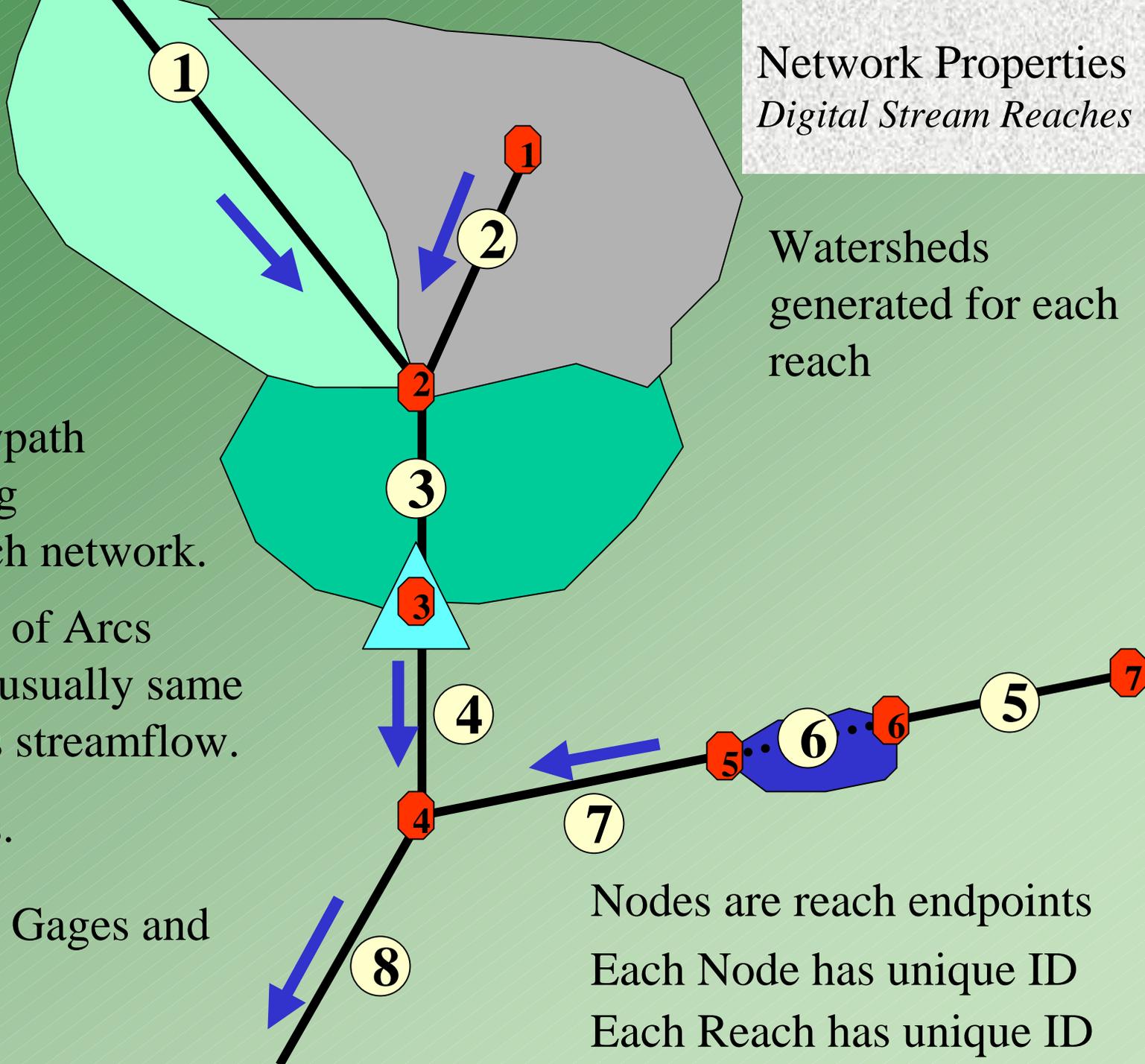
Single flowpath
representing
stream-reach network.

Orientation of Arcs
consistent, usually same
direction as streamflow.

Continuous.

Referenced Gages and
Reservoirs

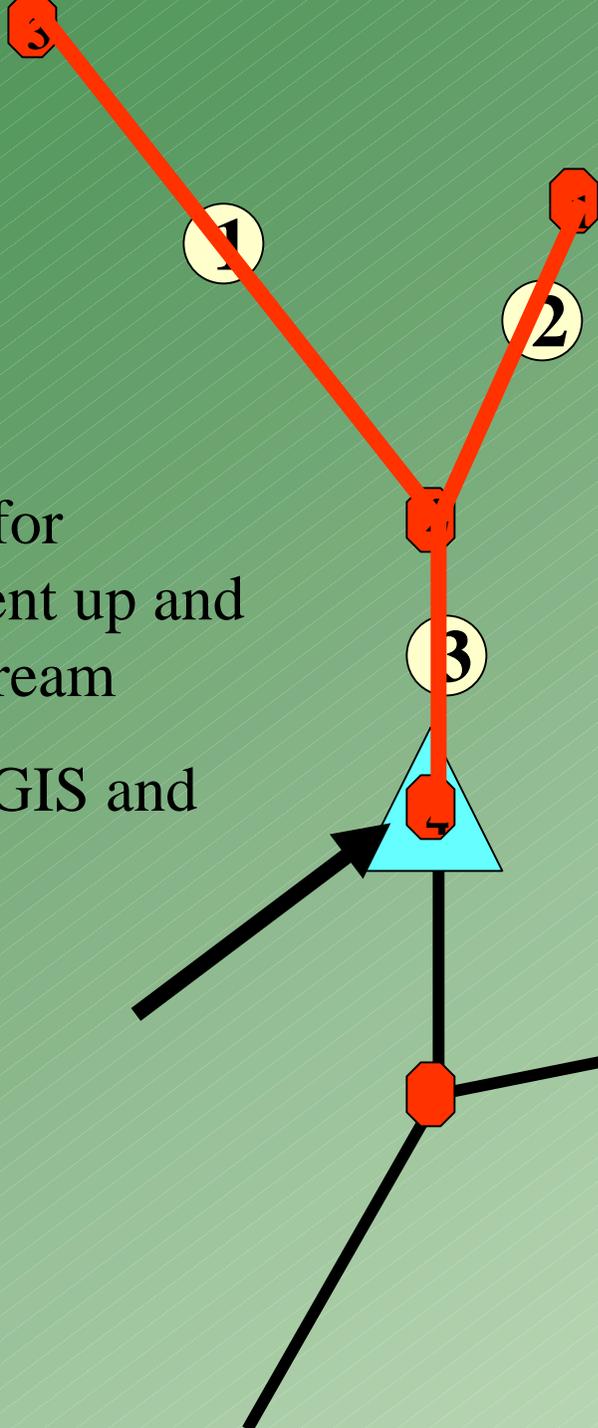
Nodes are reach endpoints
Each Node has unique ID
Each Reach has unique ID



Topology

Allows for movement up and down stream

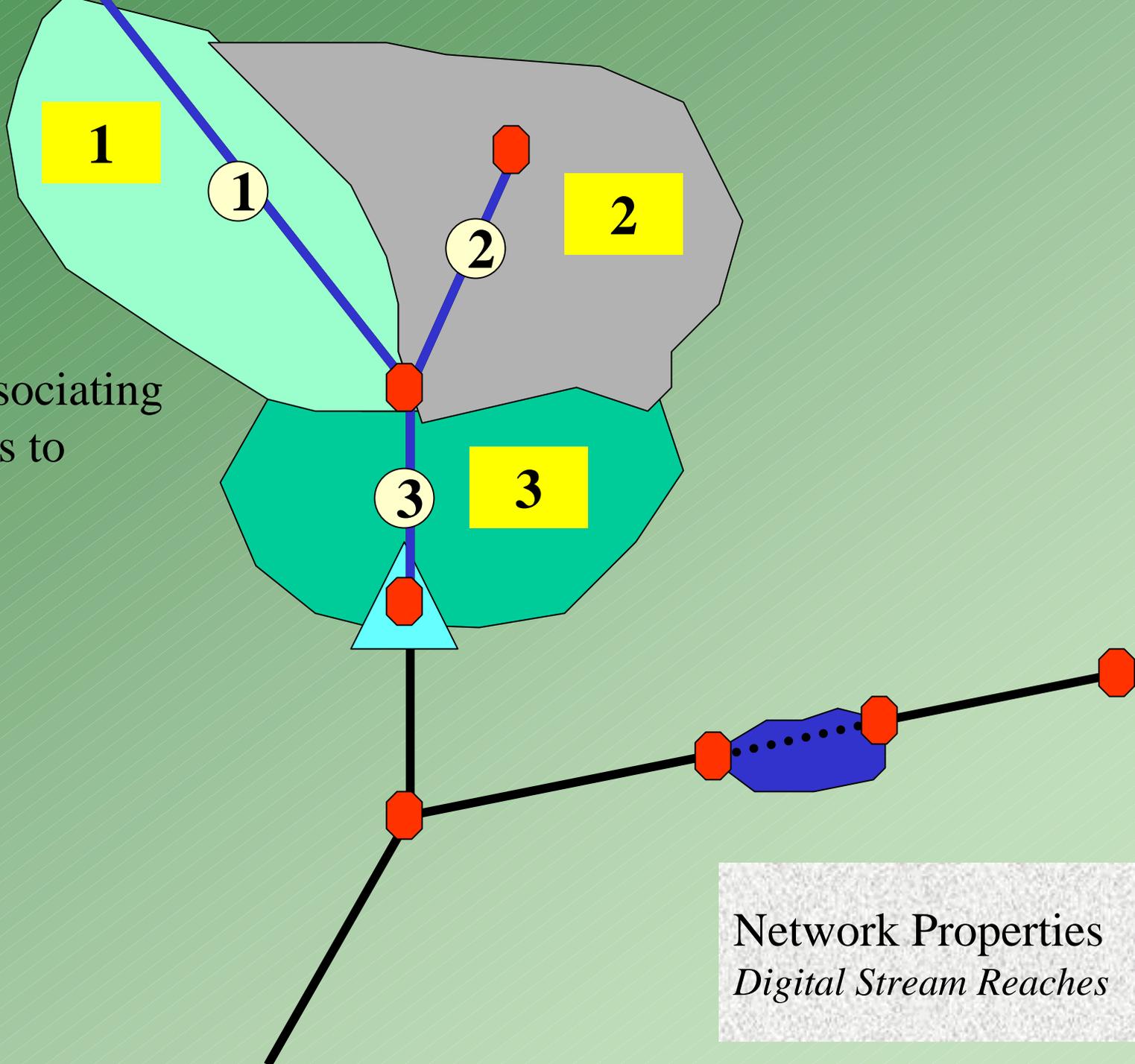
In both GIS and Model



REACH #	FNODE #	TNODE
1	3	2
2	1	2
3	2	4

Network Properties
Digital Stream Reaches

Allows for associating
stream reaches to
watersheds



Network Properties
Digital Stream Reaches

National Hydrography Dataset

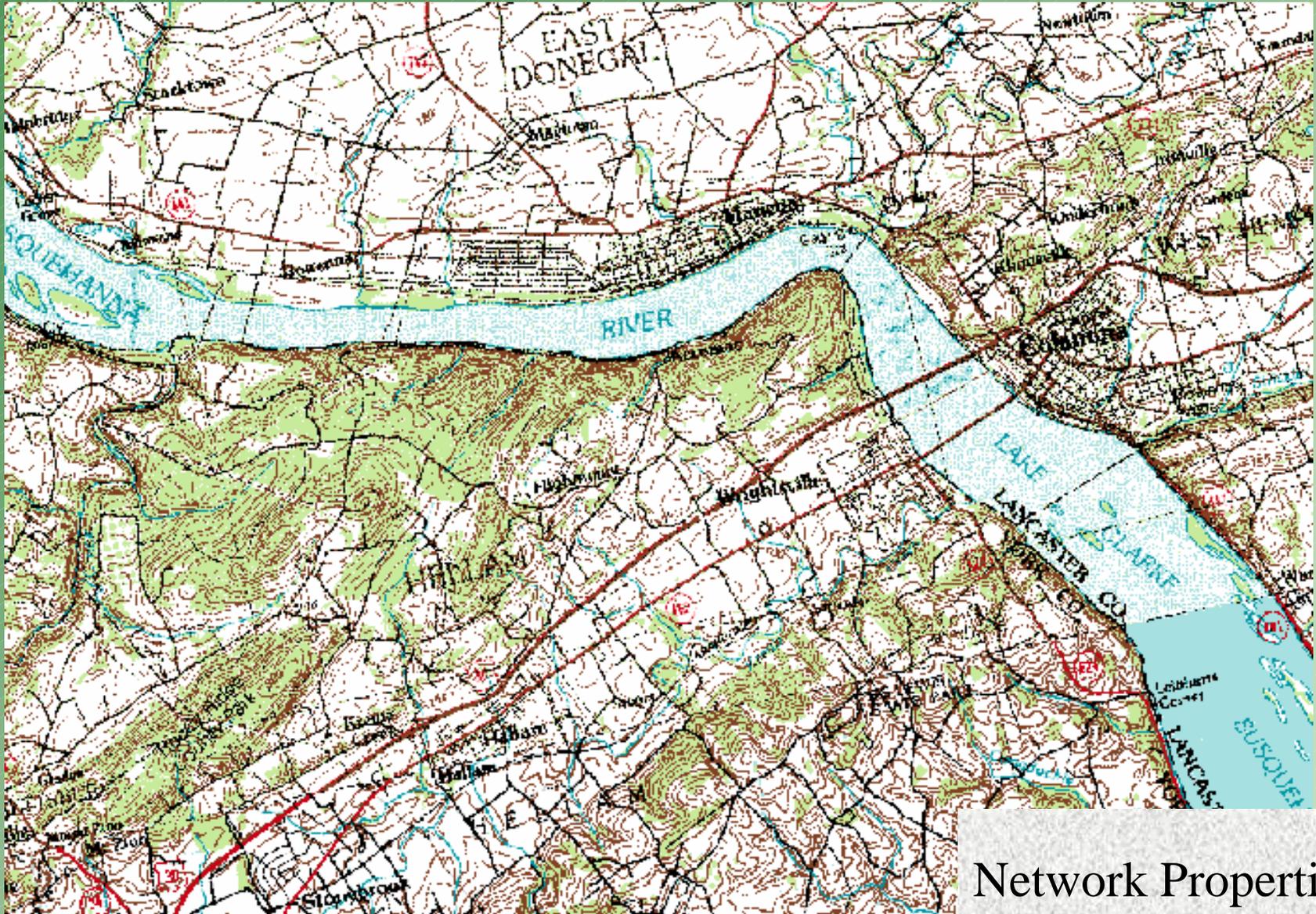


Network Properties
Digital Stream Reaches

NHD uses the same concept, but different structure

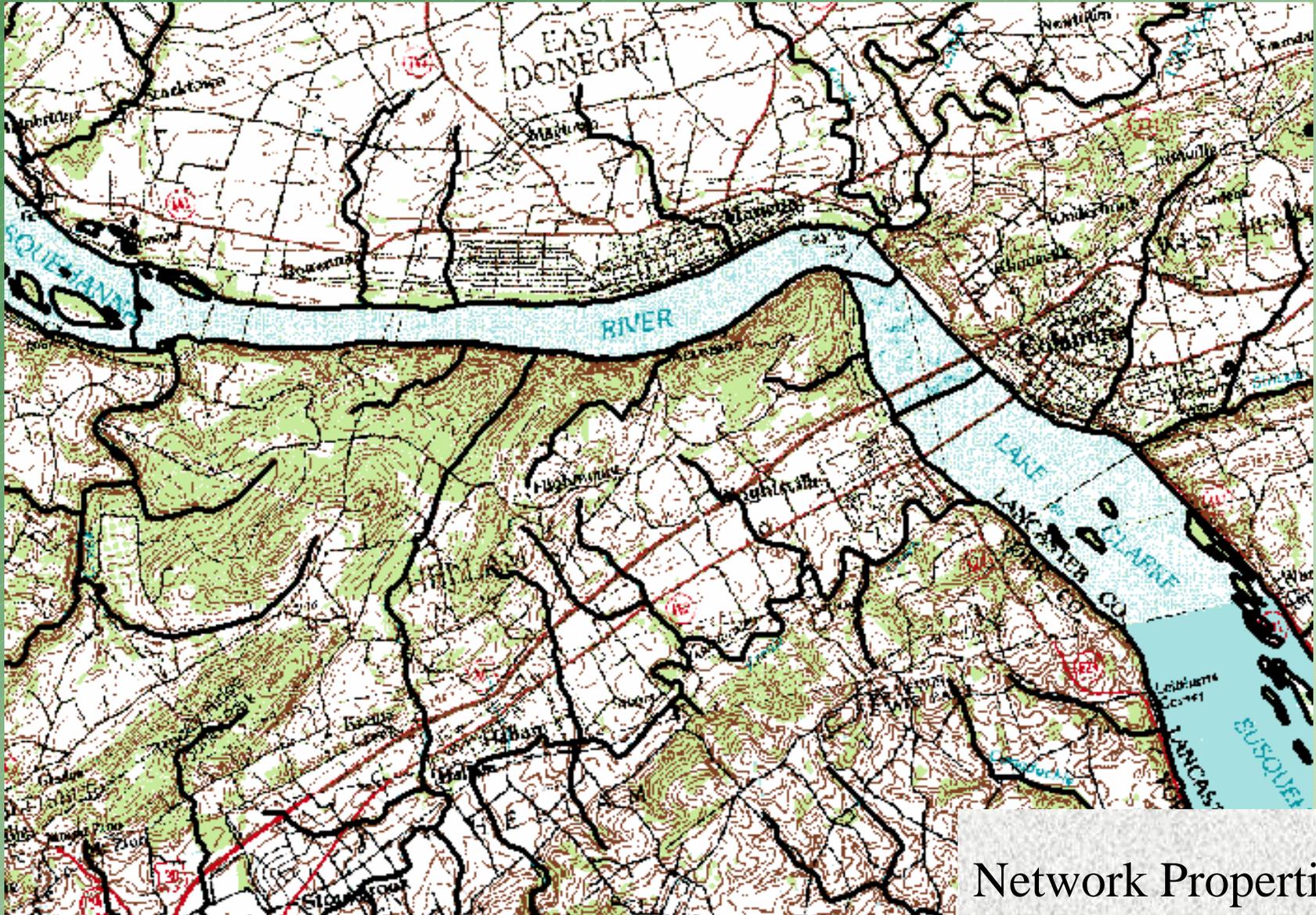
- NHD reaches.....
 - Use the dynamic segmentation model in Arc/Info
 - Directional network topology is controlled by an associated network flow table (feature based)
- Reach ids do not necessarily change at tributary junctions
- Reach ids can change along the length of a stream segment between tributary junctions
- The New England SPARROW network presentation will discuss the NHD structure further

Wide Rivers



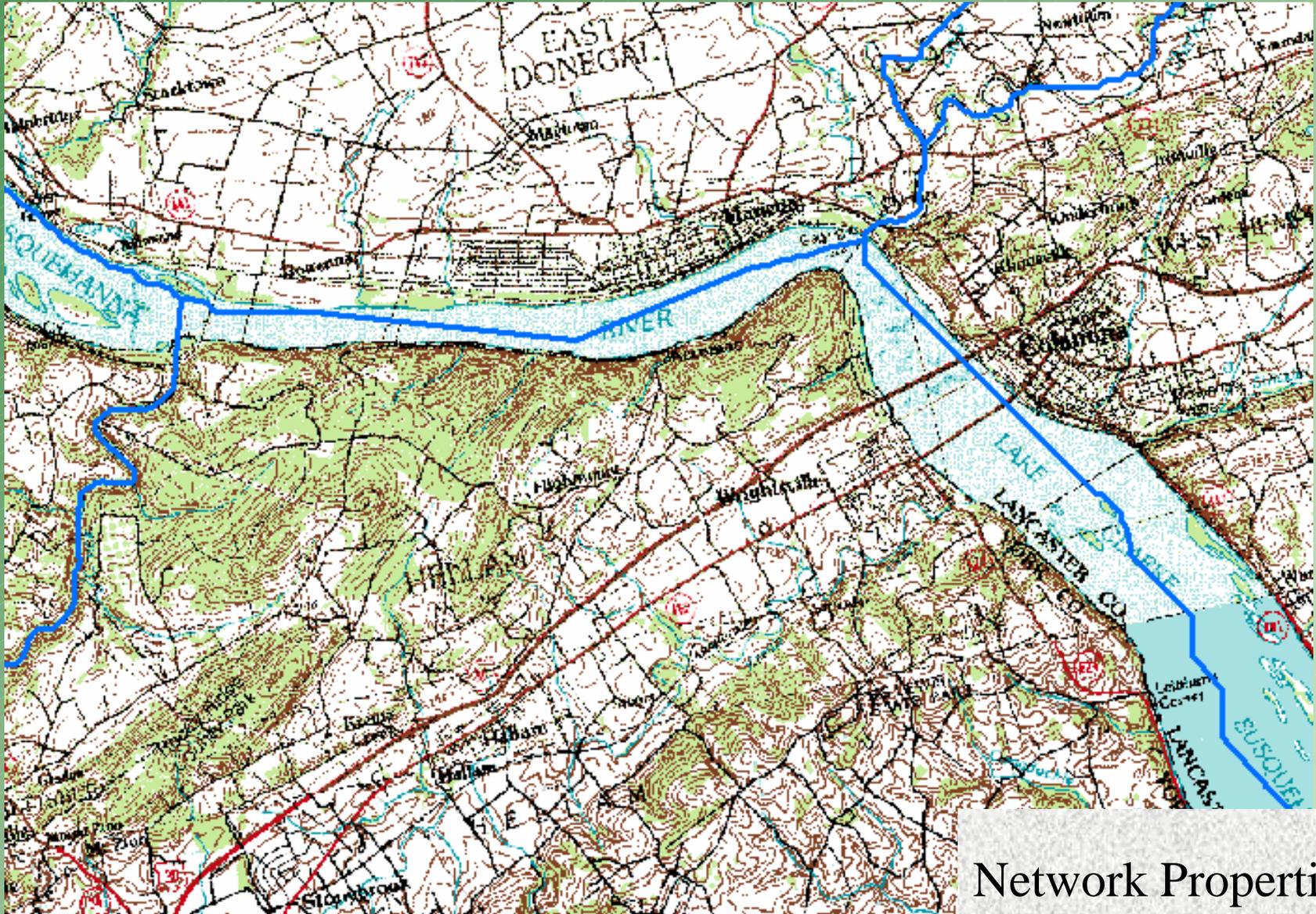
Network Properties
Digital Stream Reaches

Wide Rivers



Network Properties
Digital Stream Reaches

Wide Rivers



Network Properties
Digital Stream Reaches

Network Properties

Digital Stream Reaches

Stream Characteristics

- Streamflow
 - Used to classify streams by discharge level
 - Classification used for instream loss parameter
- Time of Travel
 - (Length / Velocity)
 - Used in estimating instream loss parameters
- Reservoir information
 - Calculation of retention time

Network Construction

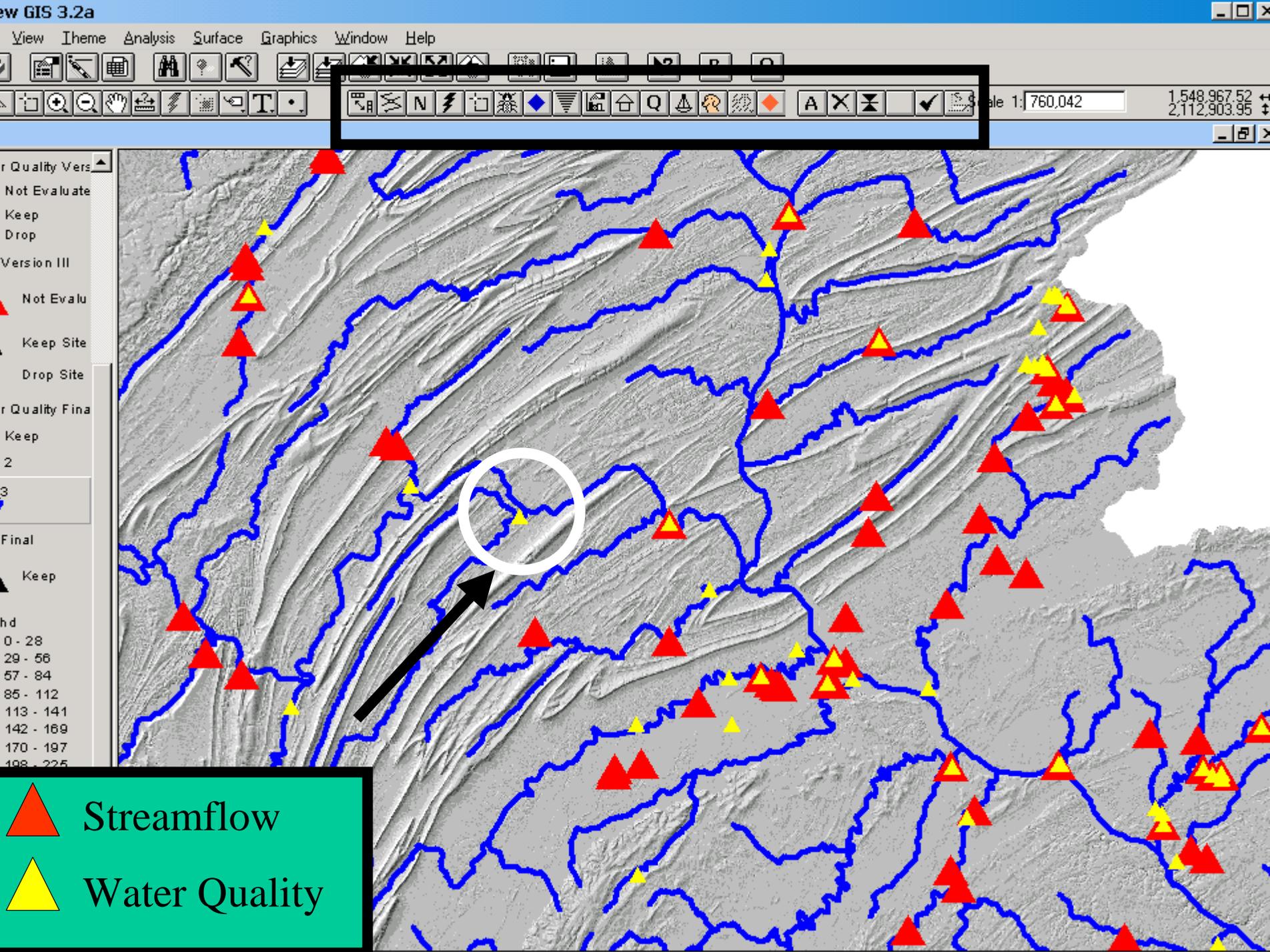
Spatially Referencing Monitoring Stations

- Matching Flow and Water-Quality
- Associating Station Locations to Reaches
- Attributing Reaches with STAID
- Attributing Unique ID
- Adjusting Time of Travel
 - Occurs if length of arc has changed

Network Construction

Spatially Referencing Monitoring Stations

- Matching Flow and Water-Quality (AV tools)
 - List QW and Flow station ID's and any other attributes
 - Using other detailed information or stream data
 - Drop unwanted sites, changes attribute and symbol
 - Keep QW or Flow station
 - Assign (or remove) QW station-id to Flow attribute table



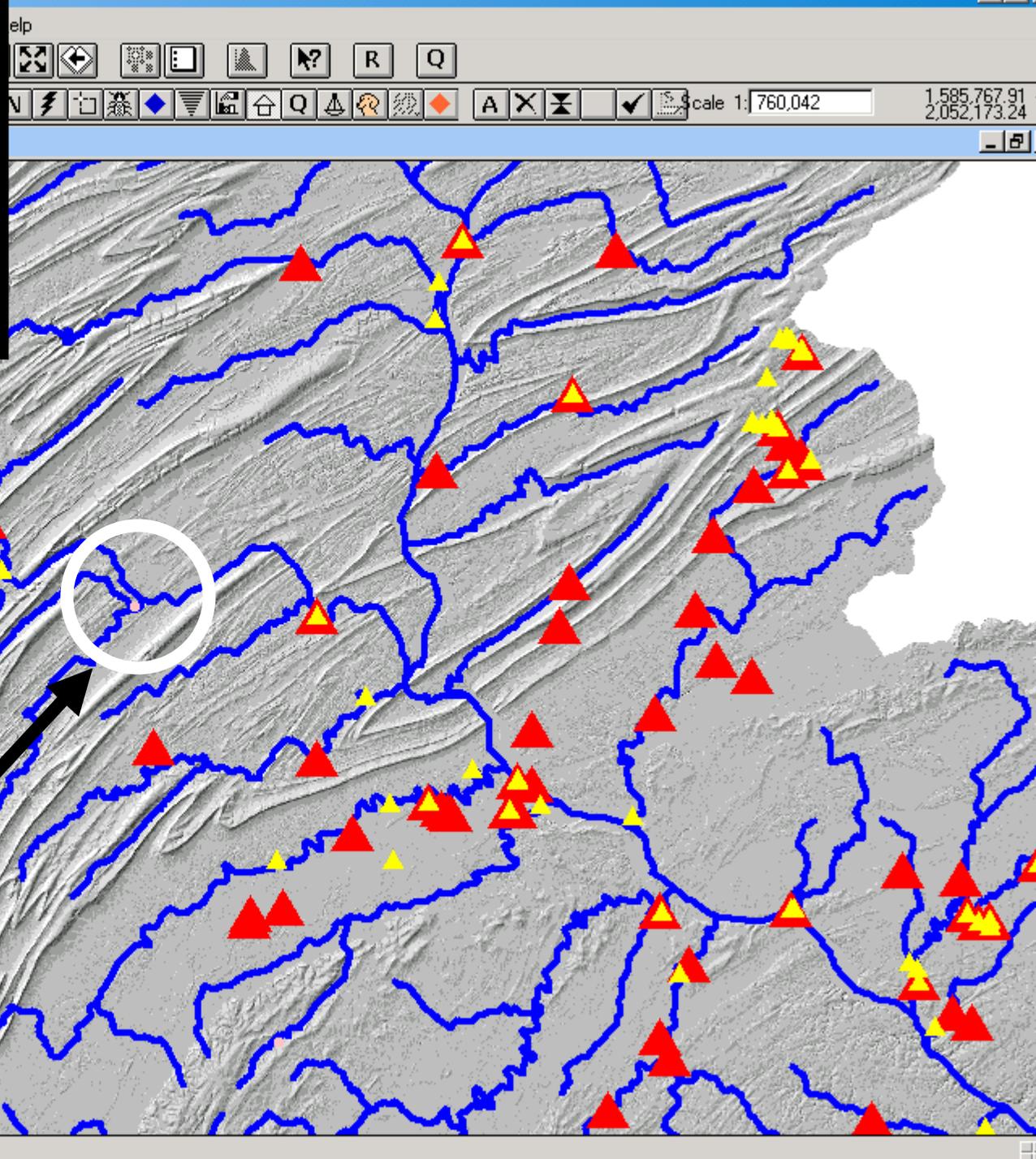
▲ Streamflow
▲ Water Quality

Changes Attribute Changes Symbol

● Dropped

- Keep Site
- Drop Site
- Water Quality Final
- Keep
- 2
- 3
- Water Final
- Keep
- shd
- 0 - 28
- 29 - 56
- 57 - 84
- 85 - 112
- 113 - 141
- 142 - 169
- 170 - 197
- 198 - 225
- 226 - 254

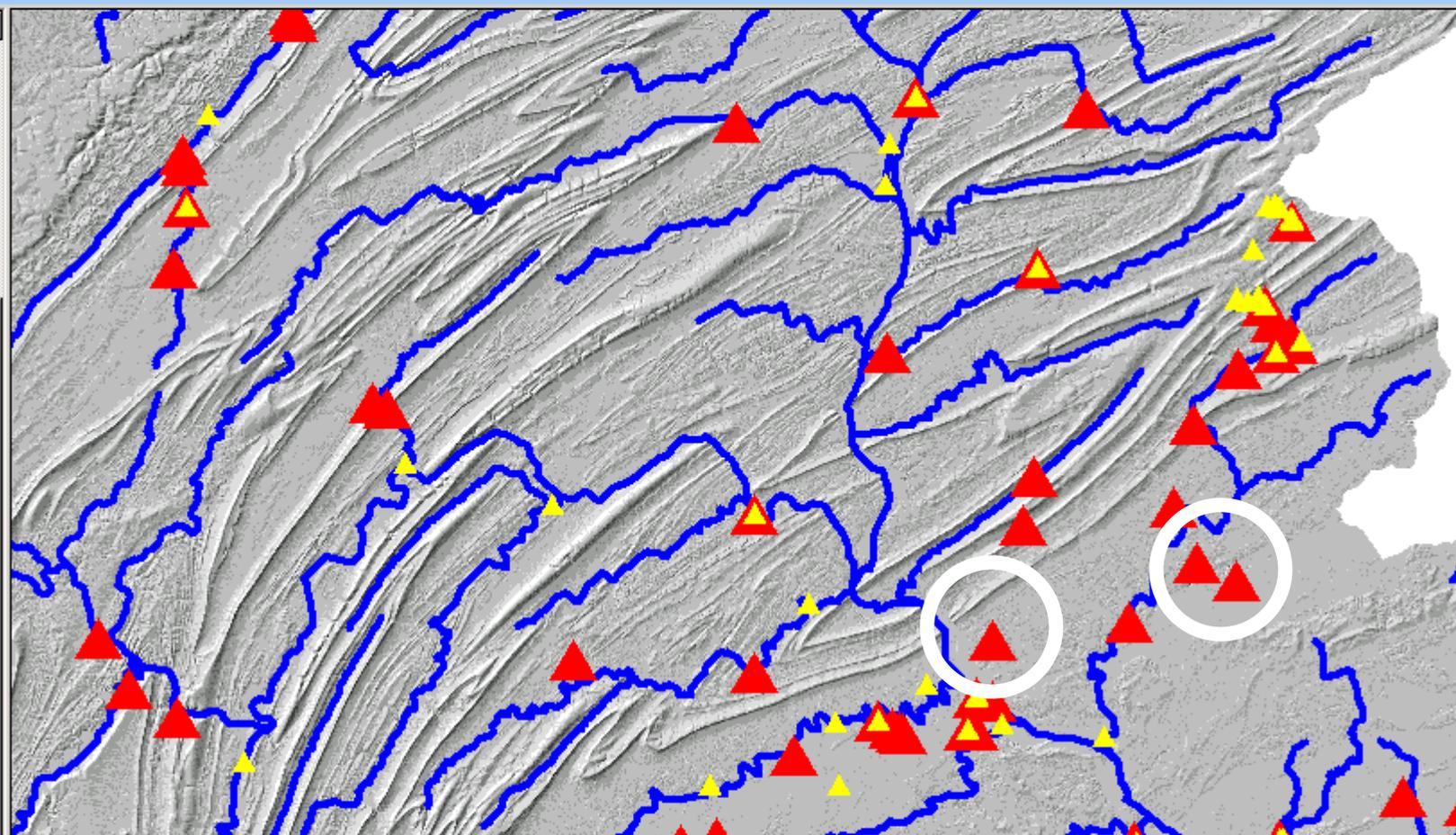
▲ Streamflow
▲ Water Quality





sites

- Water Quality Vers
 ▲ Not Evaluate
 ▲ Keep
 ▲ Drop
- Flow Version III
 ▲ Not Evalu
 ▲ Keep Site
 ▲ Drop Site
- Water Quality Fina
 ▲ Keep
 ● 2
- Erf1_3
 ▲
- Flow Final
 ▲ Keep
- Cb_shd
 ■ 0 - 28
 ■ 29 - 56
 ■ 57 - 84
 ■ 85 - 112
 ■ 113 - 141
 ■ 142 - 169
 ■ 170 - 197
 ■ 198 - 225



▲ Streamflow

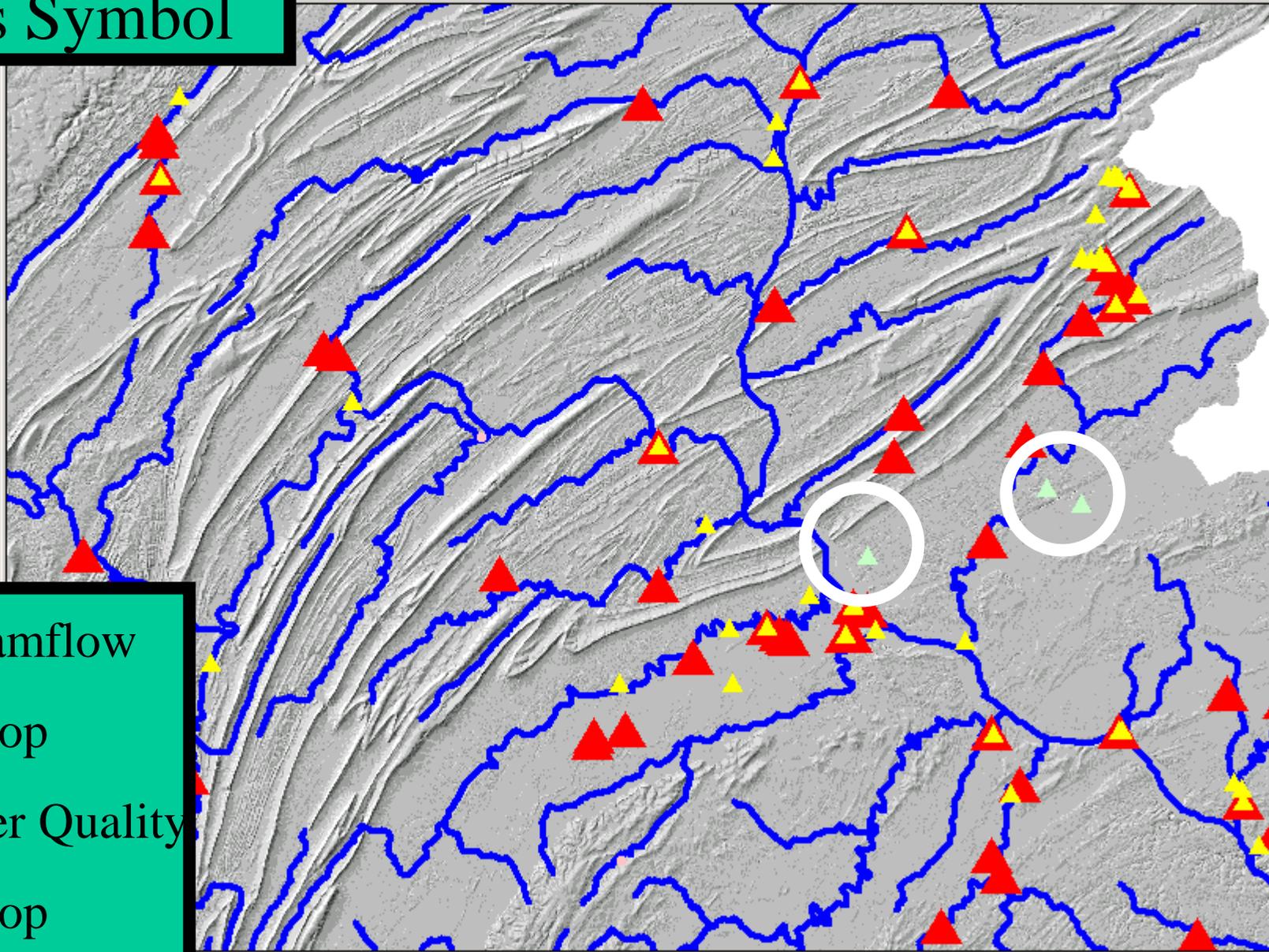
▲ Water Quality

Changes Attribute

Changes Symbol



- Keep
- Drop
- Flow Version III
- Not Evalu
- Keep Site
- Drop Site
- Water Quality Fina
- Keep
- 2
- Erf1_3
- Flow Final
- Keep
- Cb_shd

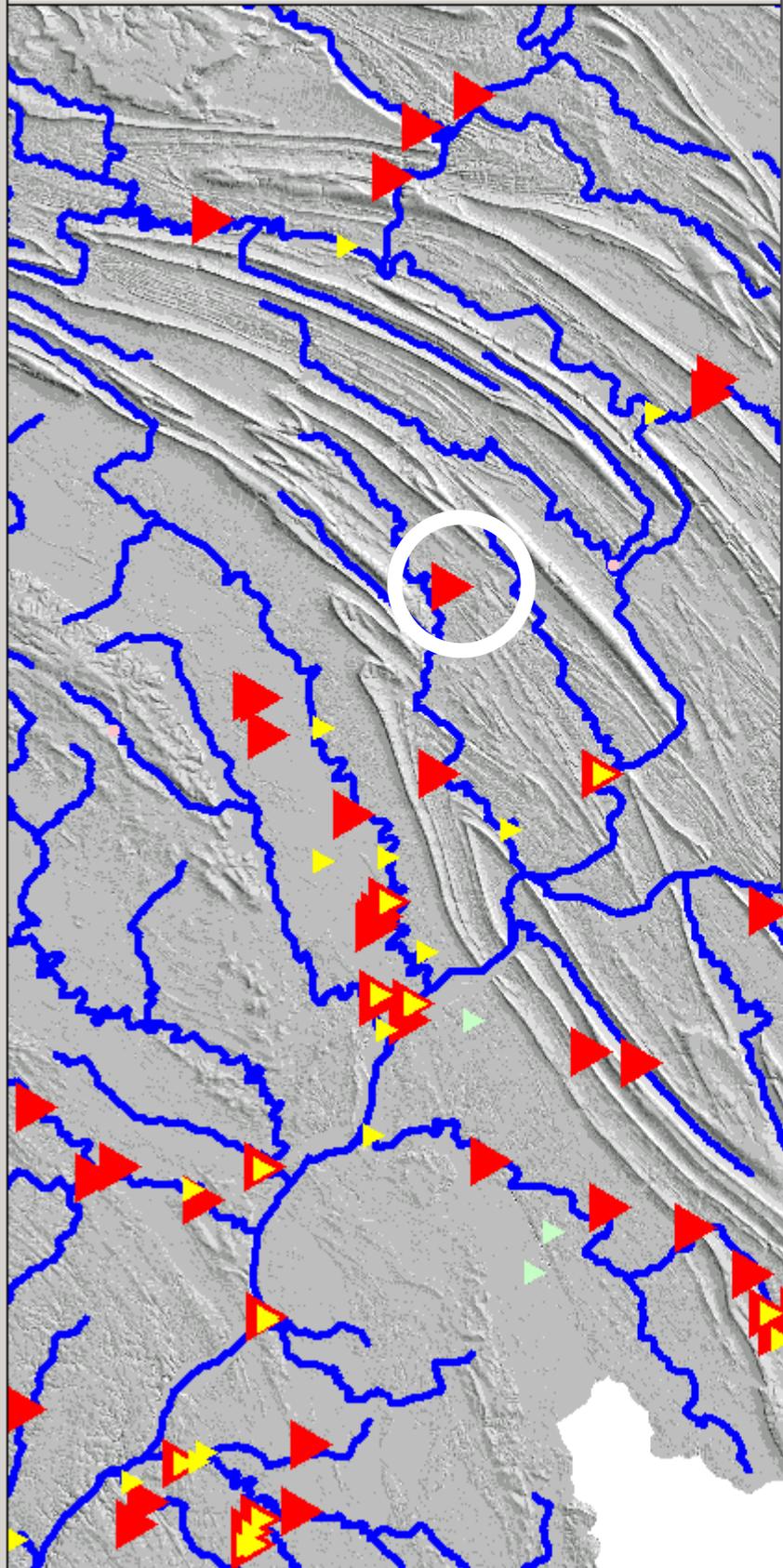


- Streamflow
- Drop
- Water Quality
- Drop

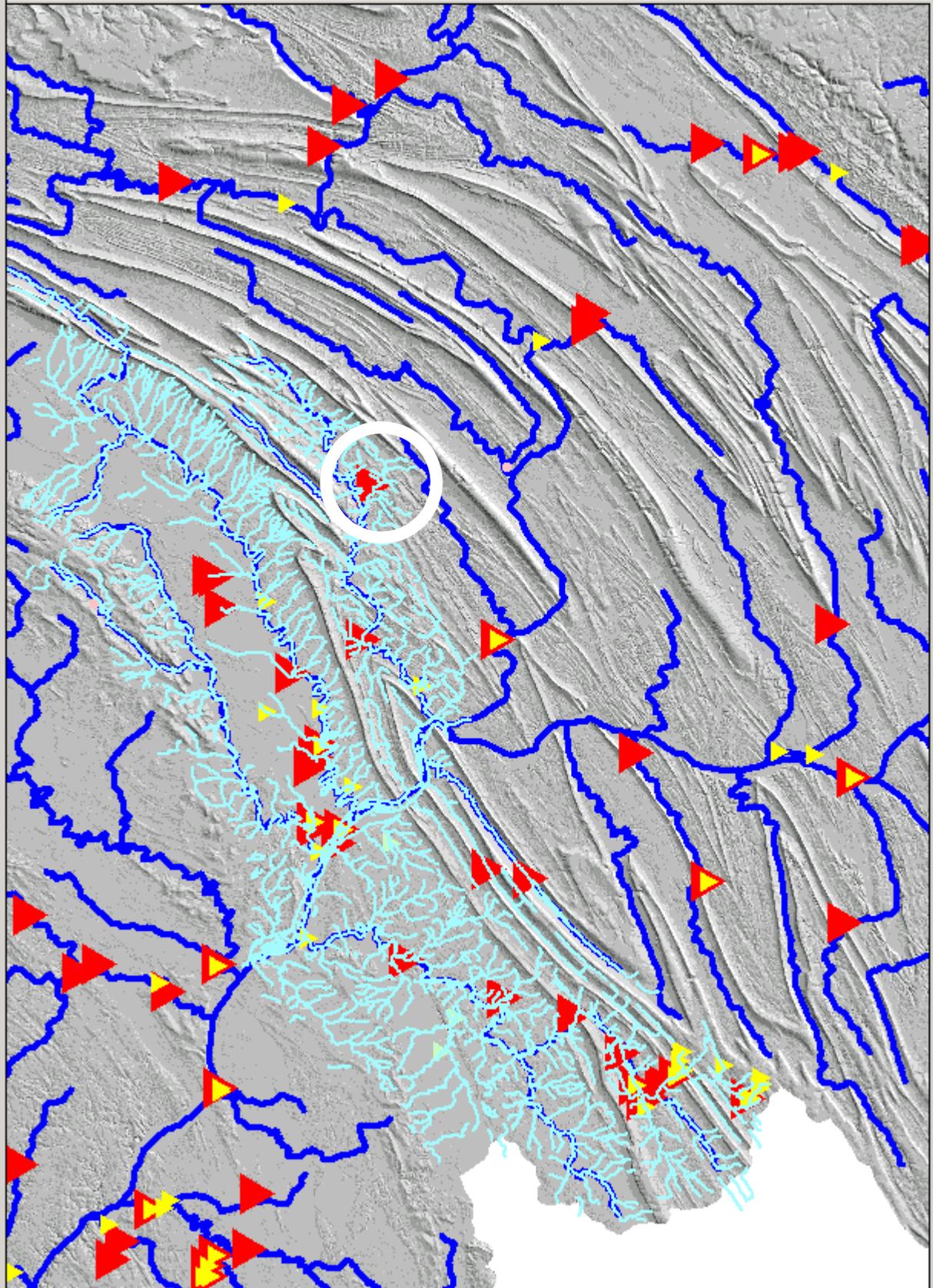
Identify Results

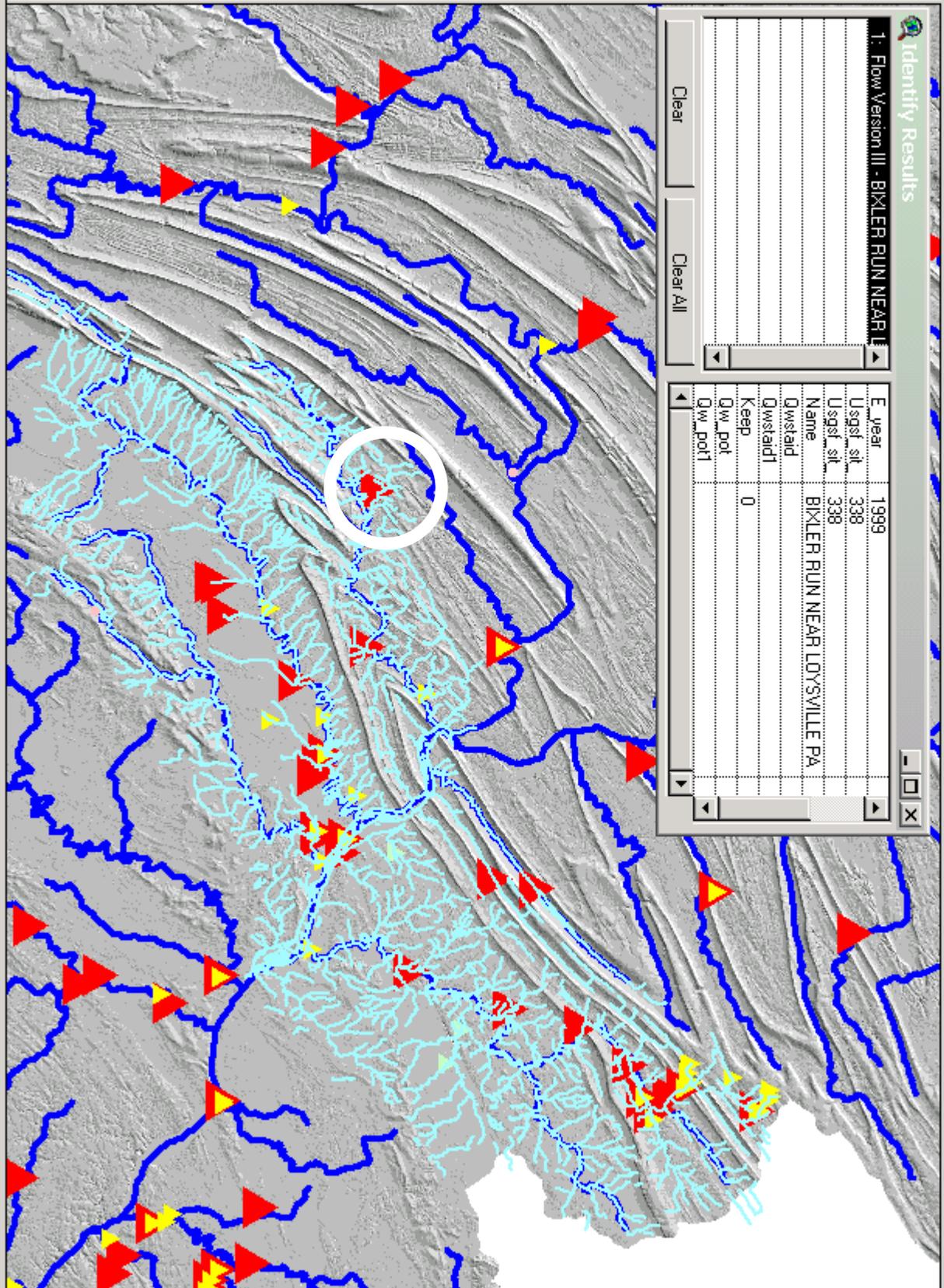
1: Erf1_3 - SHERMAN CR

Heclare	26840.971
MID	103.633
Pname	SHERMAN CR
Res	0
Res_num	0
Surfarea	0.000
Rchtype	0
Hyd_load	0.000
Rt	02050305029



2050305
 Erf1_3
 2
 Keep
 Water Quality Fina
 Drop Site
 Keep Site
 Not Evaluate
 Not Evalu
 low Version III
 Keep
 low Final
 Keep



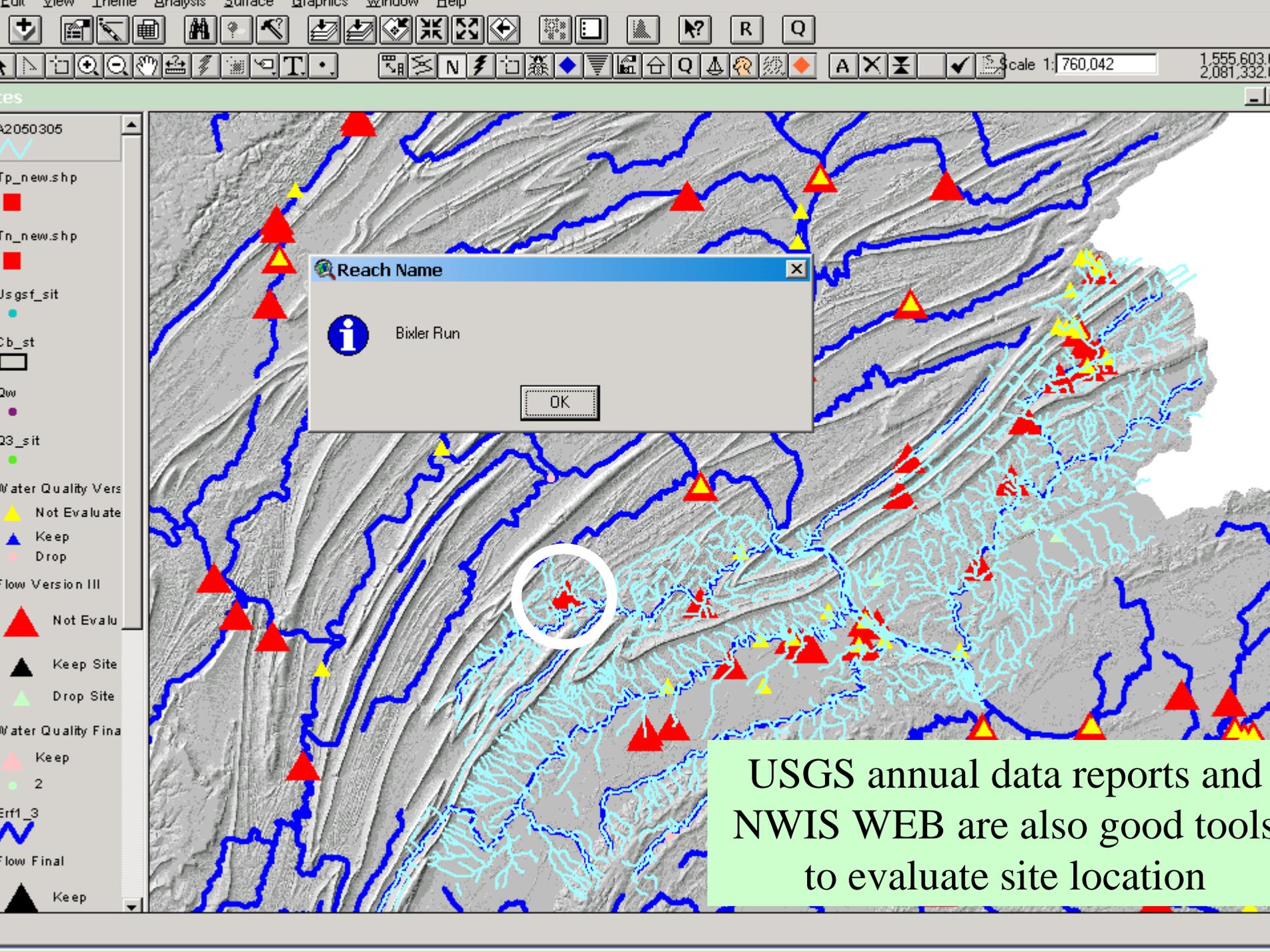


Legend:
 p_new.shp (Red square)
 n_new.shp (Red square)
 usgst_sit (Green circle)
 b_st (Black square)
 200 (Purple circle)
 33_sit (Green circle)
 Water Quality Vers (Yellow triangle)
 Not Evaluate (Yellow triangle)
 Keep (Blue triangle)
 Drop (Pink triangle)
 low Version III (Red triangle)
 Not Evalu (Red triangle)
 Keep Site (Black triangle)
 Drop Site (Black triangle)
 Water Quality Fina (Green triangle)
 Keep (Pink triangle)
 2 (Pink triangle)
 3 (Pink triangle)
 low Final (Blue triangle)
 Keep (Black triangle)

Identify Results
 1: Flow Version III - BIXLER RUN NEAR LOYSVILLE PA

E_year	1999
Usqsf_sit	338
Usgsf_sit	338
Name	BIXLER RUN NEAR LOYSVILLE PA
Qwstaid	
Qwstaid1	
Keep	0
Dw_pot	
Dw_pot1	

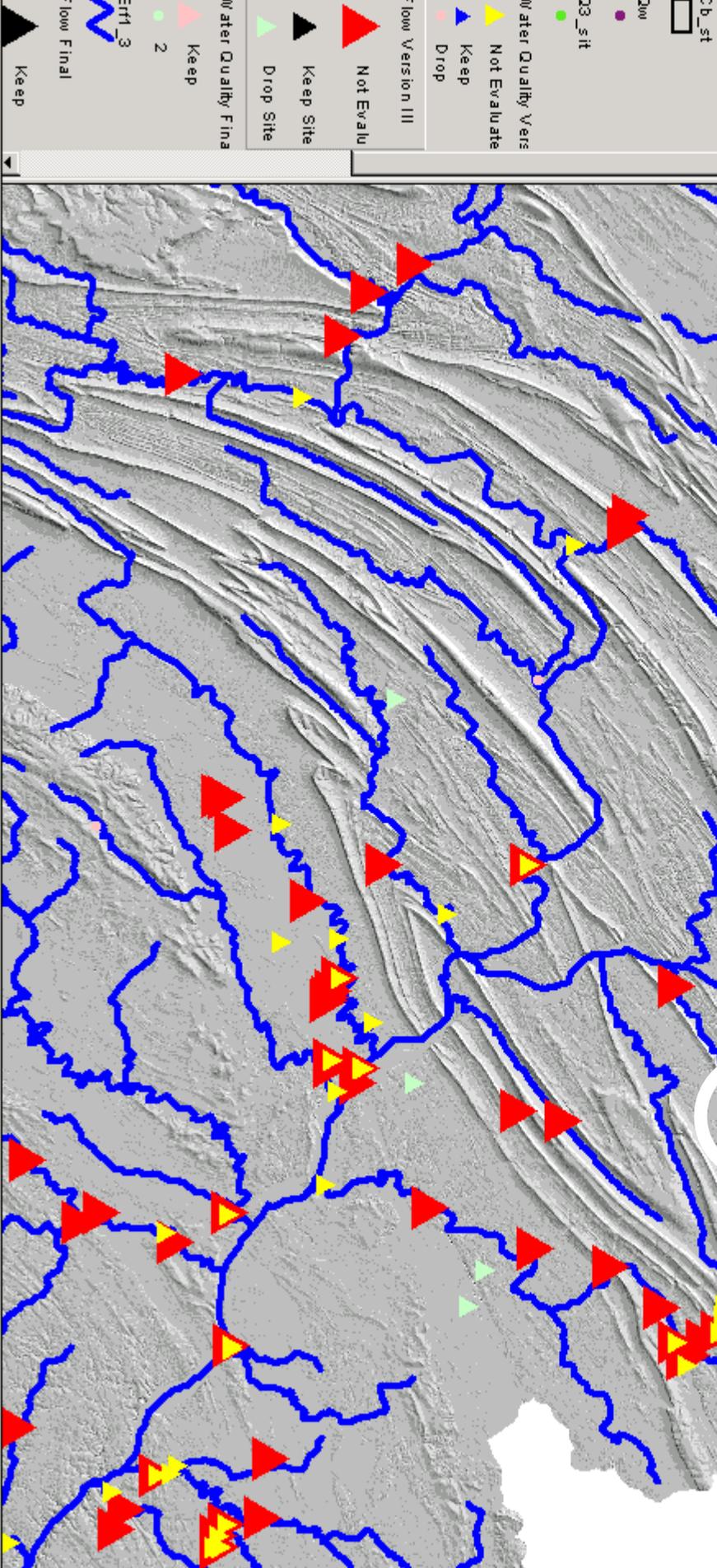
Clear Clear All



USGS annual data reports and NWIS WEB are also good tools to evaluate site location

View STAD's

 FLOW = 01555400 1992 to 1999
QW = 01555400 1993 to 2000



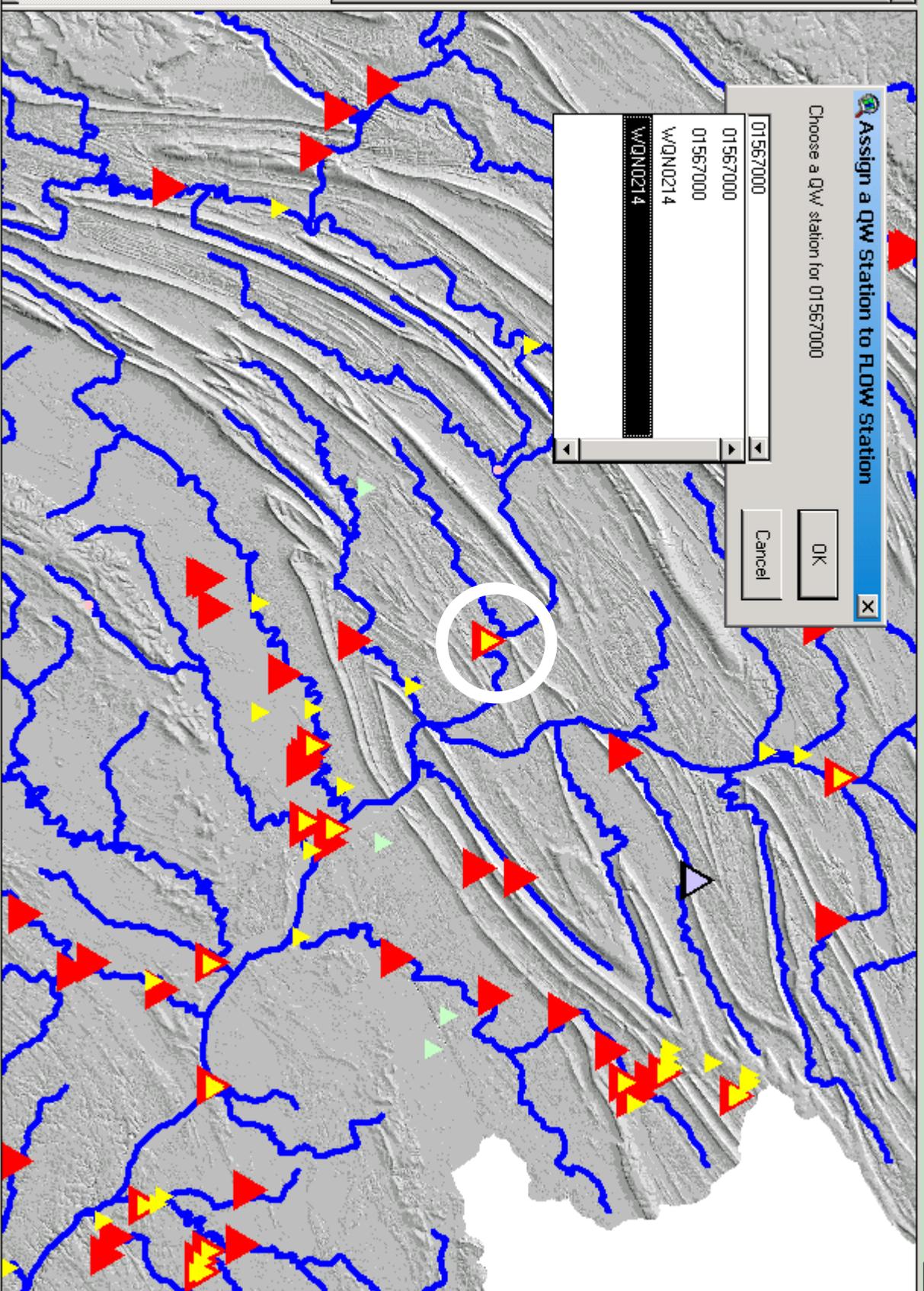
- Water Quality Vers
- Not Evaluate
- Keep
- Drop
- low Version III
- Not Evaluate
- Keep Site
- Drop Site
- Water Quality Fina
- Keep
- 2
- Keep
- low Final
- Keep

Assign a QW Station to FLOW Station

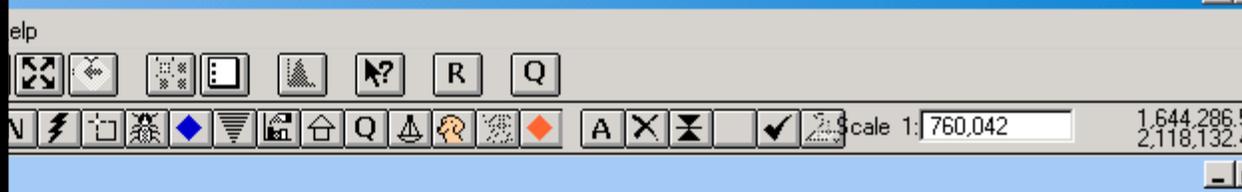
Choose a QW station for 01567000

01567000
01567000
01567000
WQW0214
WQW0214

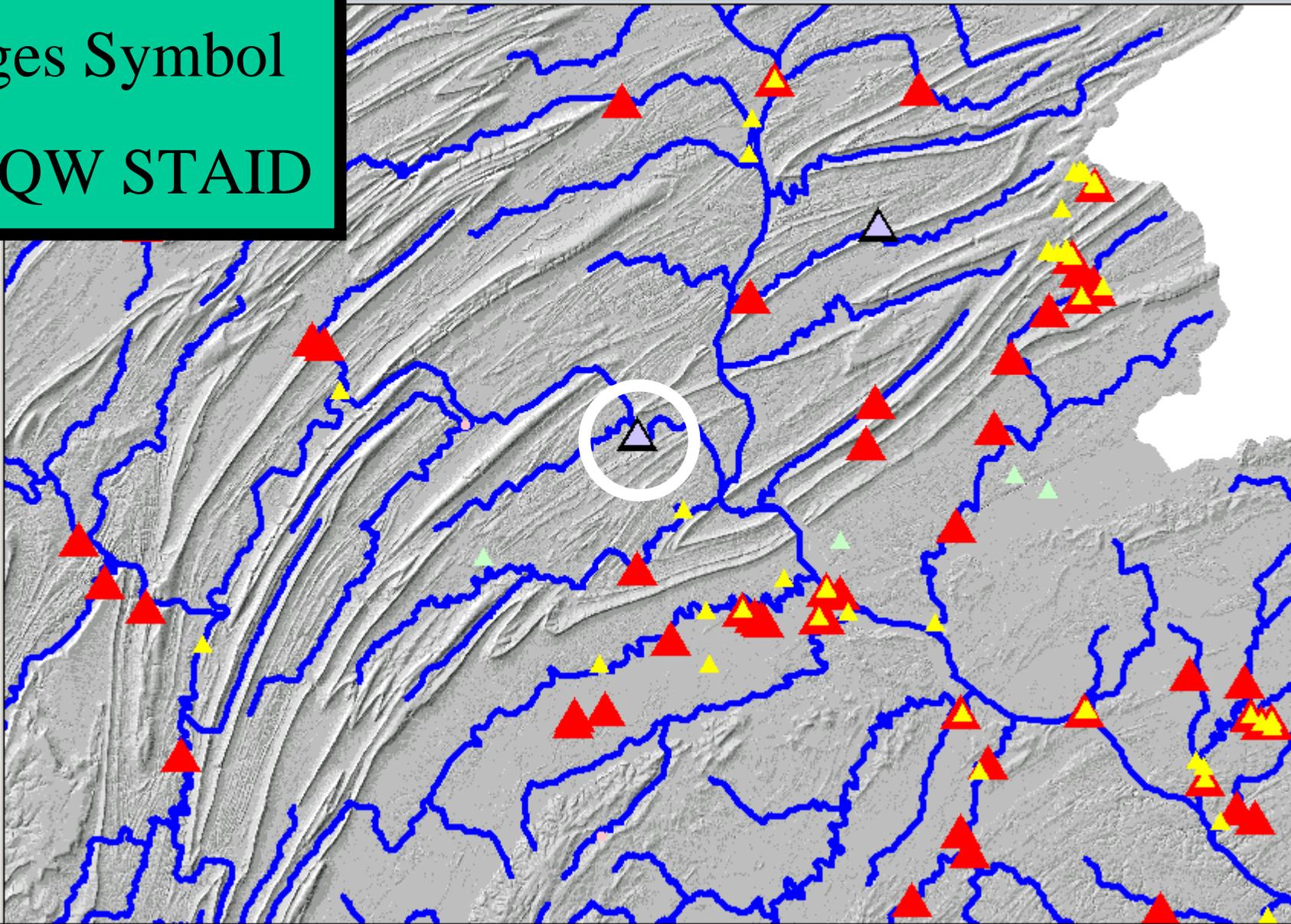
OK
Cancel

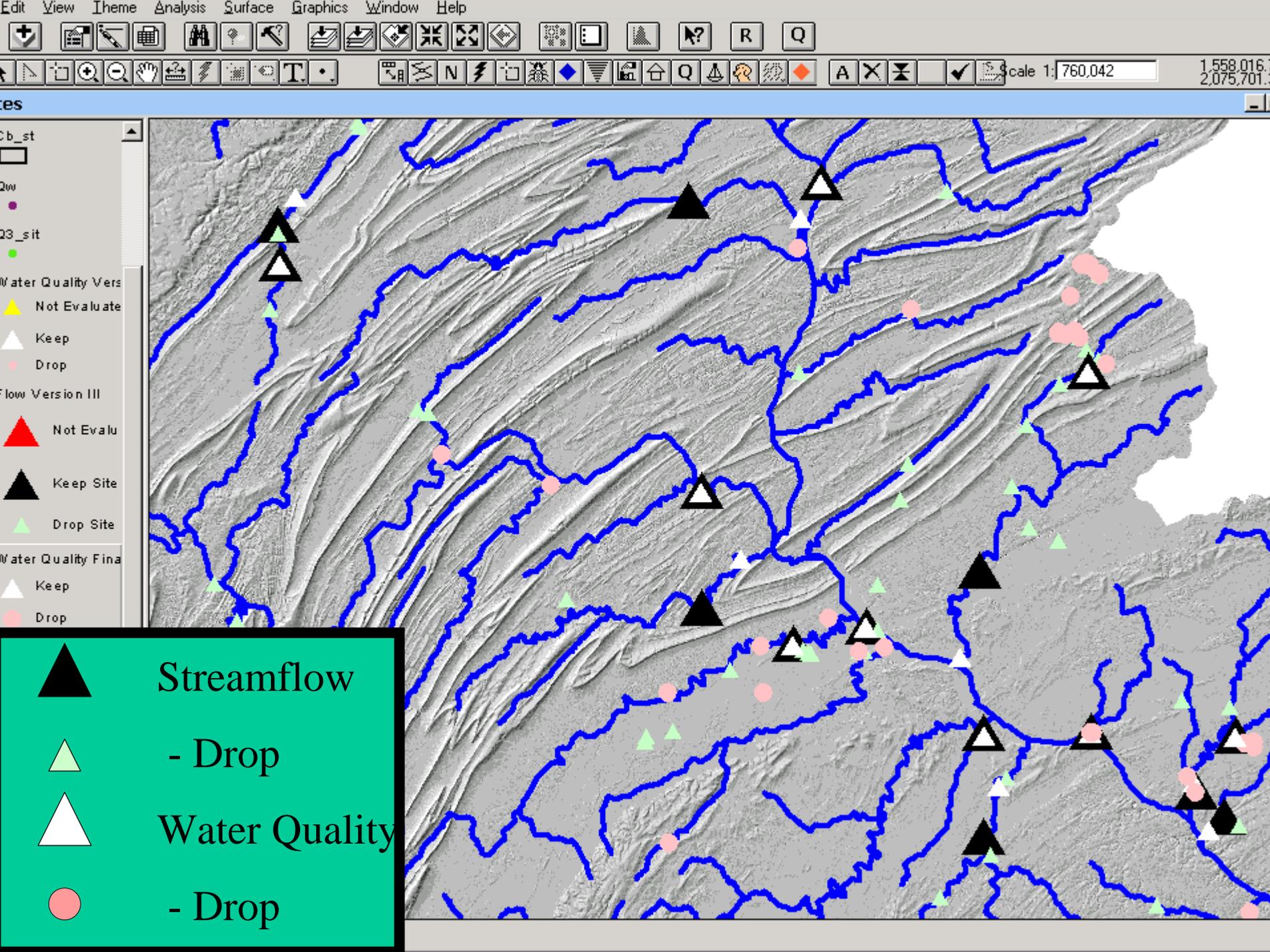


Changes Attribute
Changes Symbol
Adds QW STAID



- Cb_st
- Qw
- Q3_sit
- Water Quality Vers
- Not Evaluate
- Keep
- Drop
- Flow Version III
- Not Evalu
- Keep Site
- Drop Site
- Water Quality Fina
- Keep
- 2
- Erf1_3
- Flow Final





- cb_st
- Qw
- Q3_sit
- Water Quality Vers
 - Not Evaluate
 - Keep
 - Drop
- Flow Version III
 - Not Evalu
 - Keep Site
 - Drop Site
- Water Quality Fina
 - Keep
 - Drop

	Streamflow
	- Drop
	Water Quality
	- Drop

Scale 1: 760,042 1,558,016 2,075,701

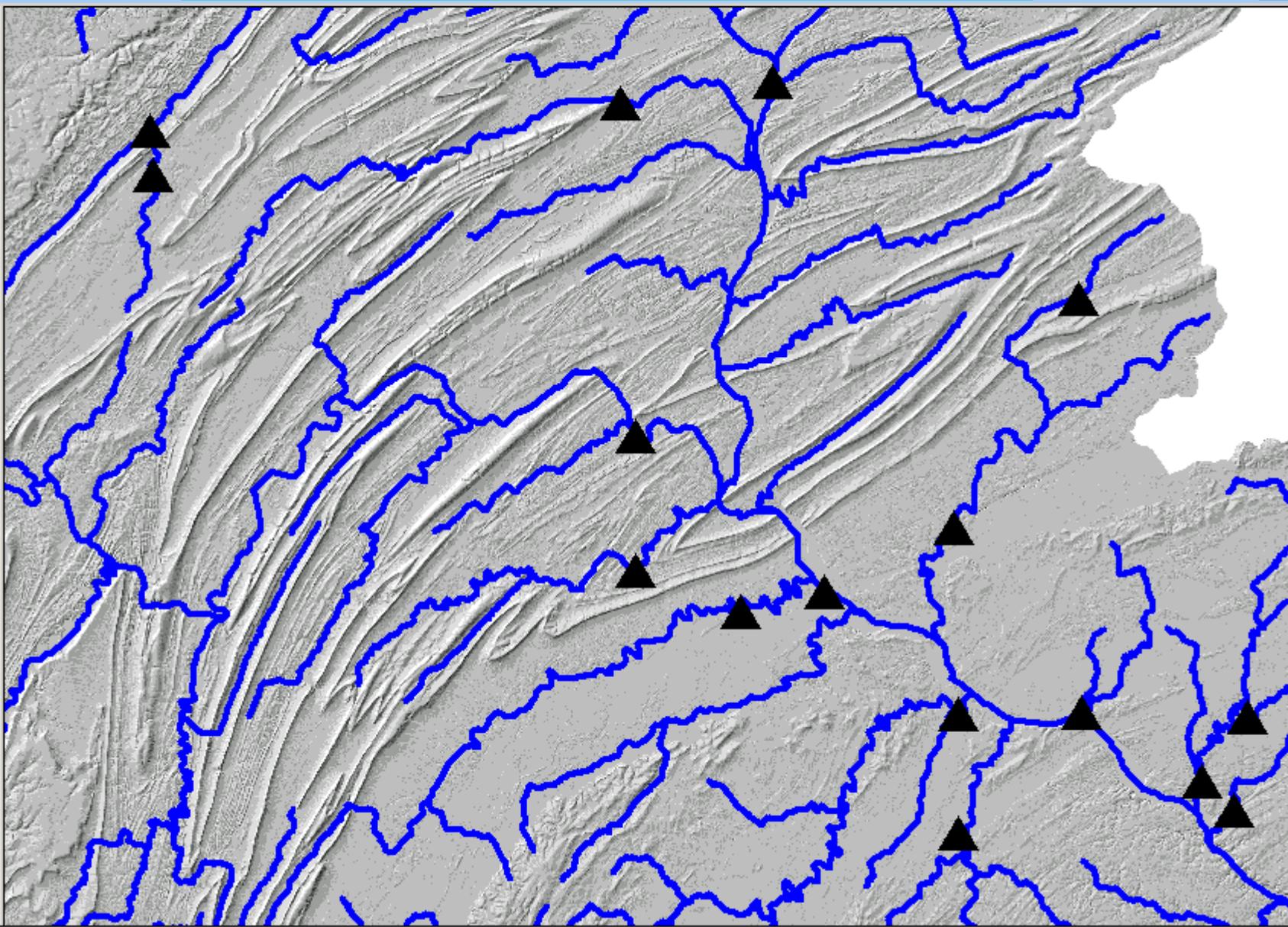


Final stations that will be associated to stream reaches

760,042 1,493,063 2,088,772

Legend for GIS layers:

- Cb_st
- Qw
- Q3_sit
- Water Quality Vers
 - Not Evaluate
 - Keep
 - Drop
- Flow Version III
 - Not Evalu
 - Keep Site
 - Drop Site
- Water Quality Fina
 - Keep
 - 2
- Flow Final
 - Keep
- Erf1_3
- Cb_shd
 - 0 - 28
 - 29 - 56
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 - 142 - 169
 - 170 - 197

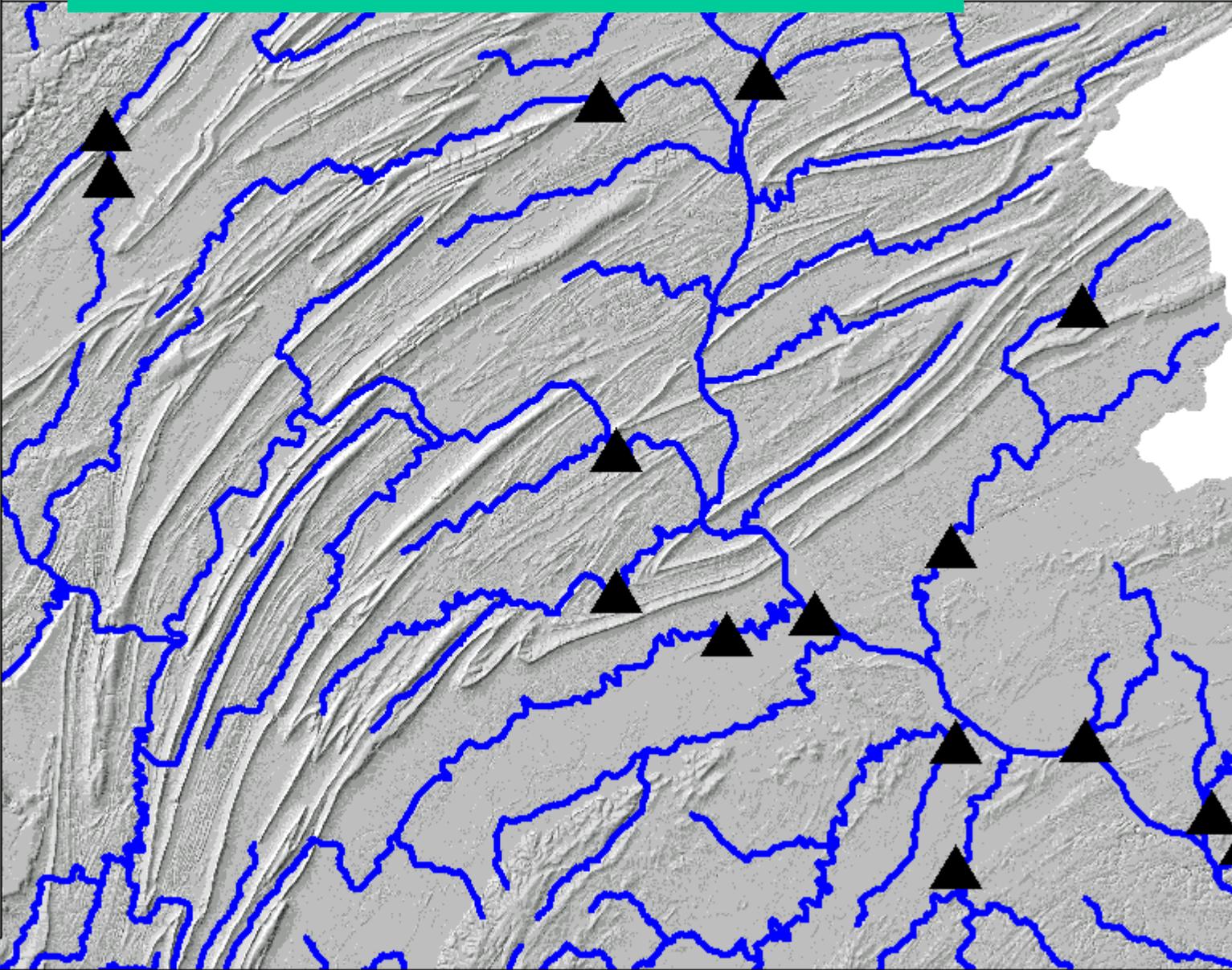




Final stations that will be associated to stream reaches

0 of 435 selected

Staid	Qwstaid
01636500	1636500
01643000	1643020
01646500	1646580
01654000	1654000
01658500	1658500
01660100	1660110
01668000	1668000
01673000	1673000
01674500	1674500
02035000	2035000
02038850	2038850
02041650	2041650
01660400	AAUA014.51
01638480	ACAX004.57
01656120	ACER006.00
01656000	ACER016.46
01646000	ADIF000.86
01634500	BCDR013.29
01624800	BCST012.32
01632082	BLNV001.22
01625000	BMDL001.83
01633000	BNFS070.67
01632000	BNFS093.53
01622000	BNTH014.08
01635500	BPSG001.36
01632900	BSMT004.60
01629500	BSSF054.20
01628500	BSSF100.10
01627500	BSTH007.80
01626000	BSTH027.85
02011500	-BCC004.71
02032400	-BKM002.01
02015700	-BLP000.79
02027800	-RIUF002.10



scale 1:760,042 1.49 2.08

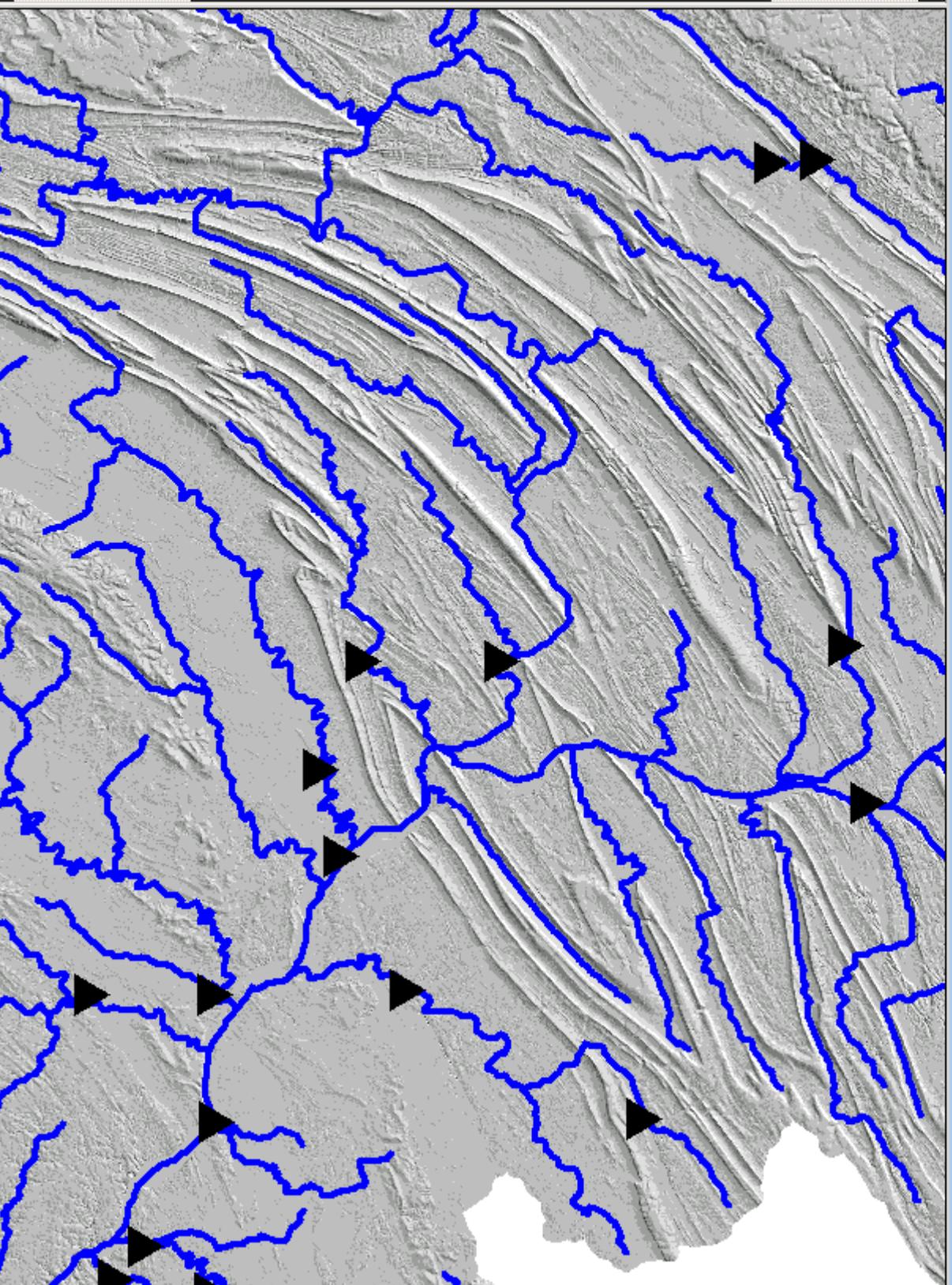
sites

Legend and symbology options:

- Cb_st
- Qw
- Q3_sit
- W ater Quality Vers
- Not Evaluate
- Flow Version III
- W ater Quality Fina
- Keep
- Flow Final
- Keep
- Drop Site
- Keep Site
- Not Evalu
- Keep
- 2
- Keep
- Ert1_3
- Cb_shd

Legend values:

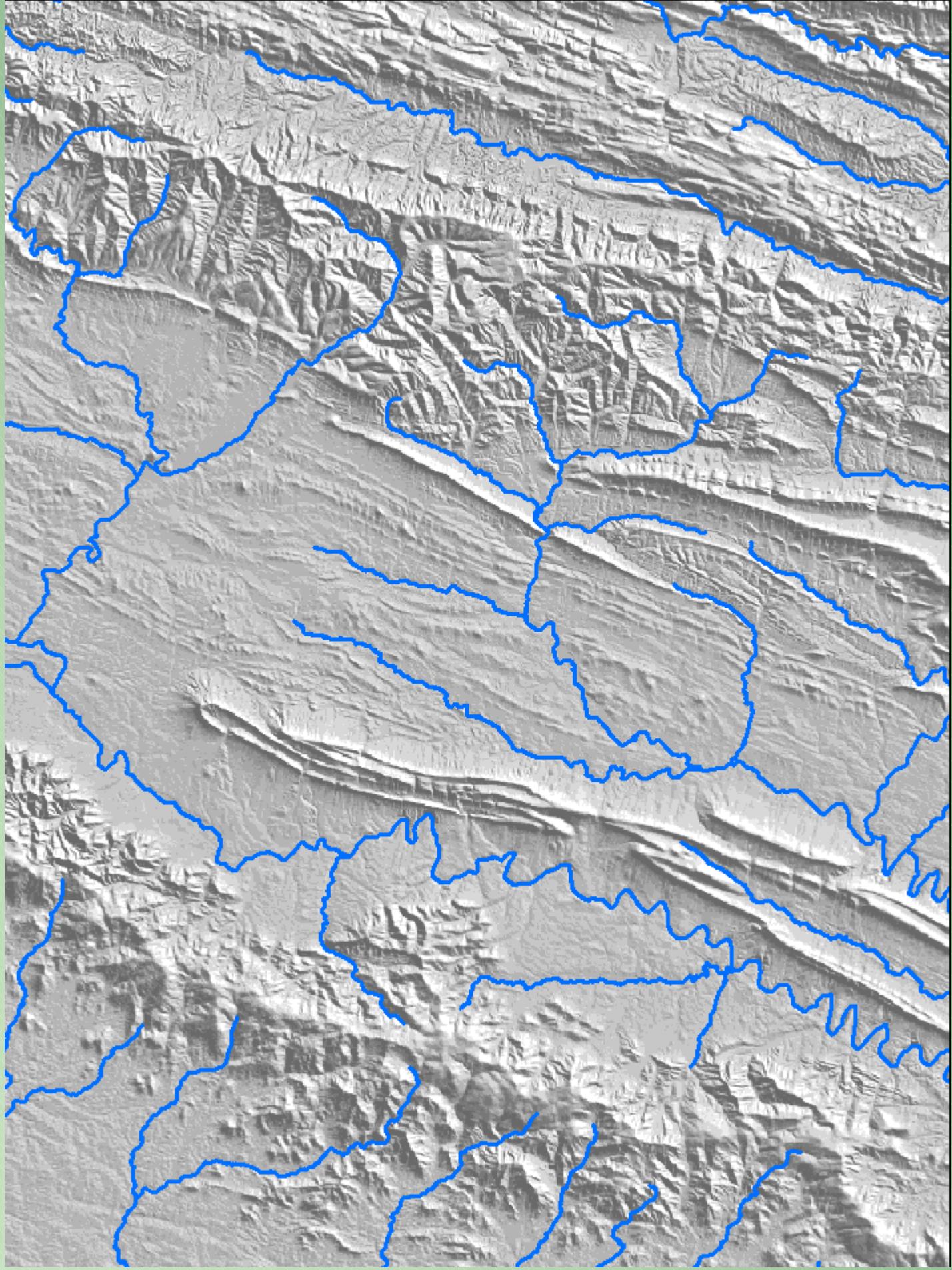
- 0 - 28
- 29 - 56
- 57 - 84
- 85 - 112
- 113 - 141
- 142 - 169
- 170 - 197

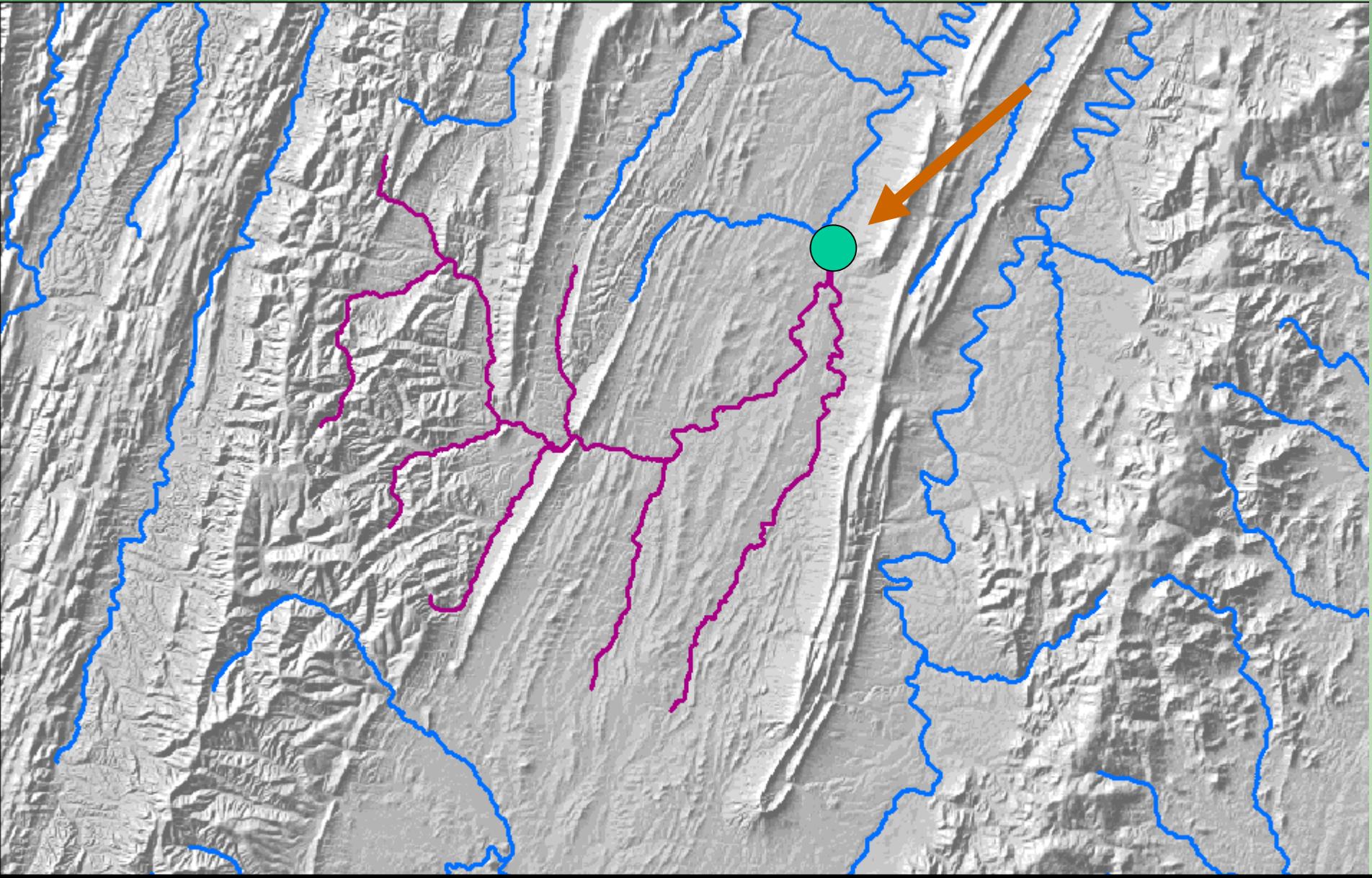


Network Construction

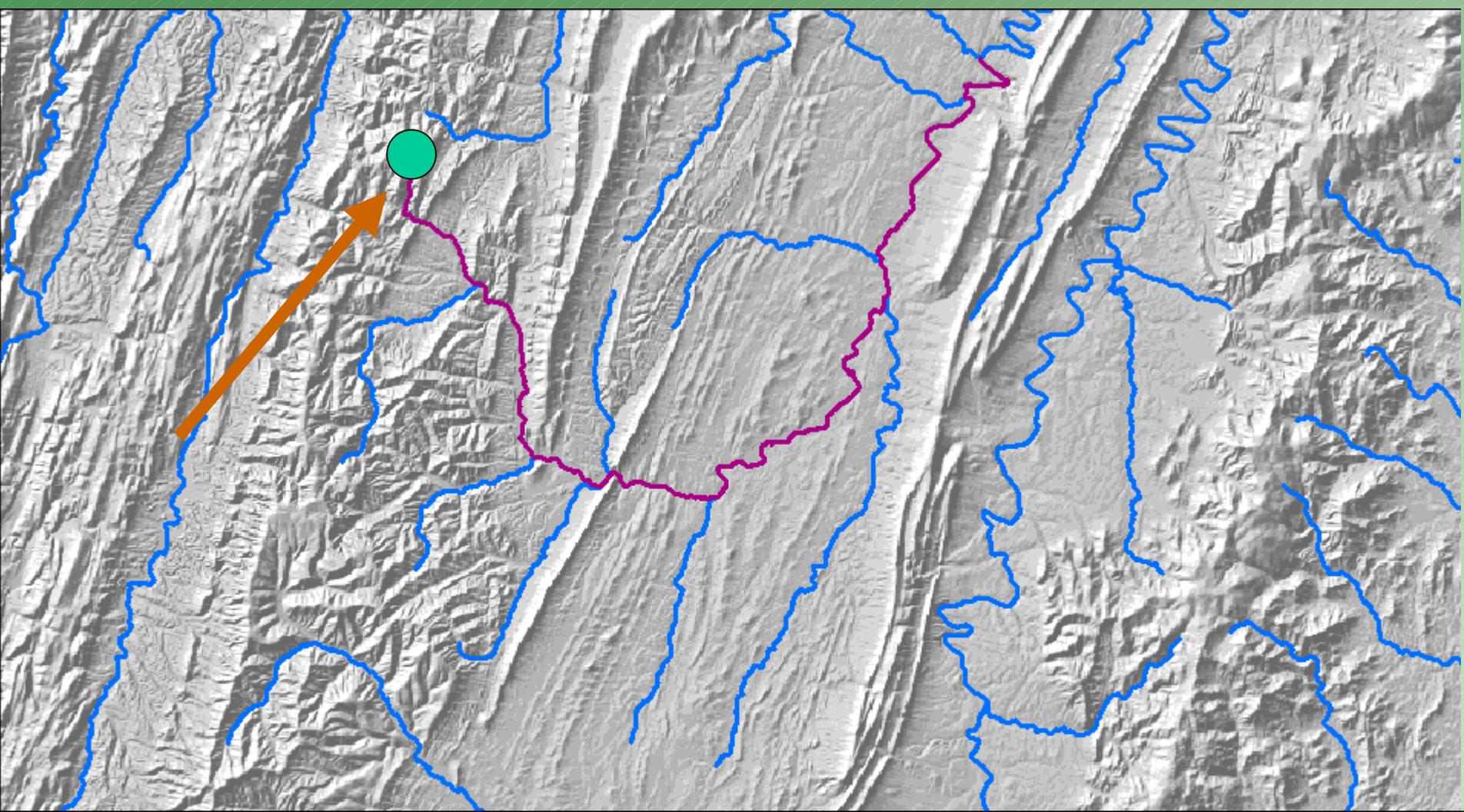
Flow Path Verification

- Tracing
 - ArcInfo (Arcplot trace)
 - NHD Tools
- Visual comparison
 - Digital Raster Graphics
 - Digital Ortho Quads
 - Other vector data sets
- Dealing with multiple arcs per reach
 - Reach based information
 - Arc based information



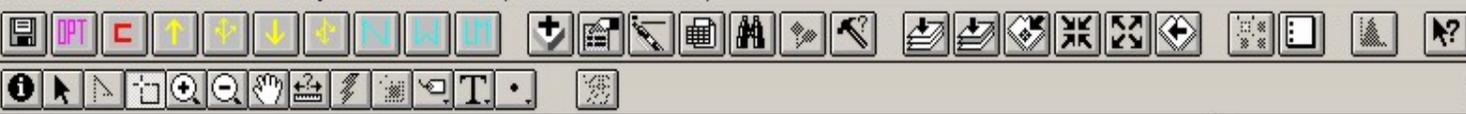


Arcplot: TRACE upSTREAM %.ecov% up.erf1 # * erf1_end erf1_prev
READSELECT up.erf1



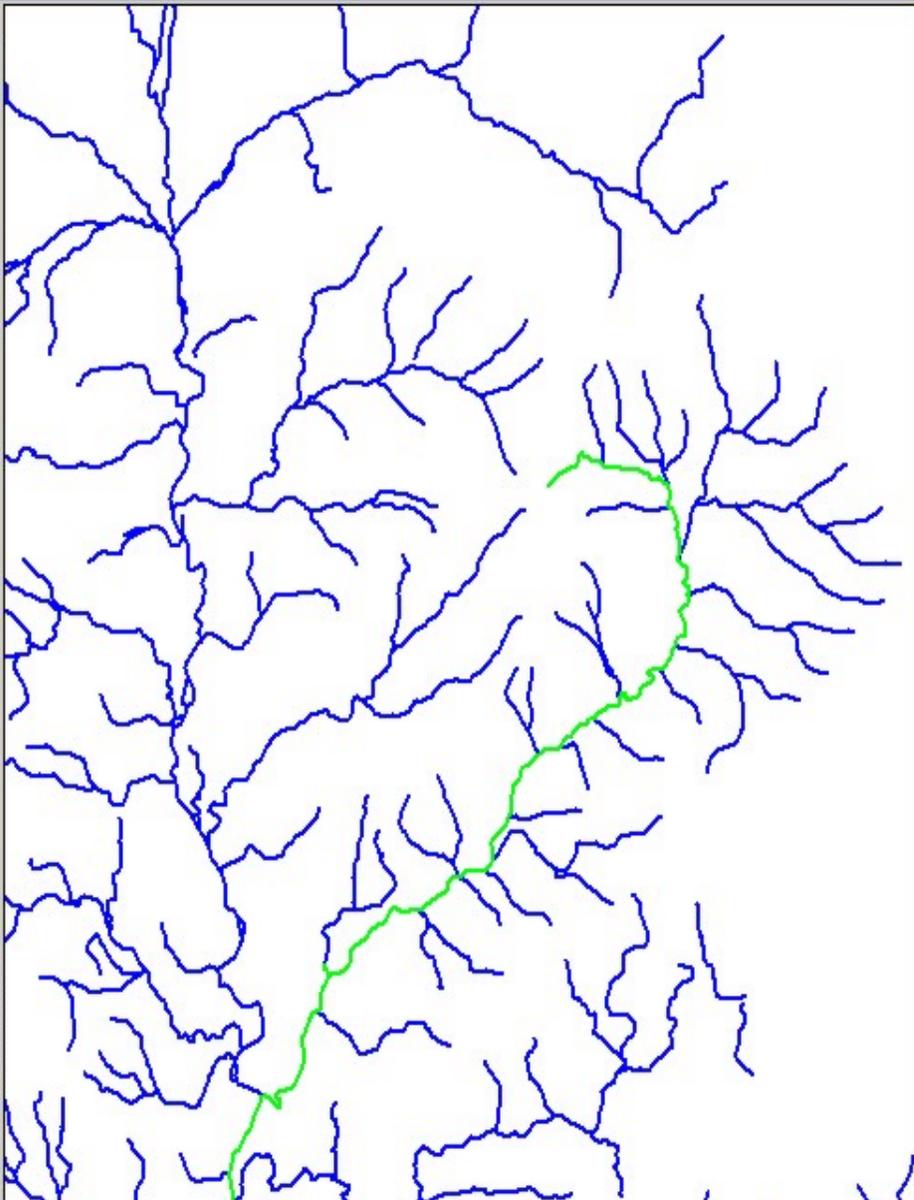
Arcplot: TRACE downSTREAM %ecov% down.erf1 # * erf1_end
erf1_prev

READSELECT down.erf1



WS: merrimack

- Merri_dm
- Reach (nhd.route.rc)
 - ARTIFICIAL F
 - CANAL/DITC
 - CONNECTOP
 - PIPELINE
 - STREAM/RIV
- Drain (nhd.route.dra)
 - 0
- 0D Landmark (nhd.p)
 - GAGING STA
 - RAPIDS
 - SPRING/SEE
 - WATER FALL
- 1D Landmark (nhd.l)
 - DAM/W EIR
 - NONEAR THE
 - RAPIDS
 - TUNNEL
- Waterbody Reach (nhd.wb)
 - LAKE/POND
 - RESERVOIR
 - SEA/OCEAN
 - STREAM/RIV
 - SW AMP/MAF
- Waterbody (nhd.reg)
 - LAKE/POND
 - RESERVOIR
 - SEA/OCEAN
 - STREAM/RIV
 - SW AMP/MAF
- 2D Landmark (nhd.l)
 - INUNDATION
 - RAPIDS
- Node (nhd.node)
- DUU (nhd.duu.regio)
 - 01060003
 - 01070001



Drain (nhd.route.drain)

Shape	Drain#	Drain-id	Com_id	Rich_com_id	Wb_com_id
PolyLine	186	186	6729585	6734541	-9999
PolyLine	187	187	6729587	6734441	-9999
PolyLine	188	188	6729589	6734531	-9999

Reach (nhd.route.rch)

Shape	Rich#	Rich-id	Com_id	Rich_code	Rich_date
PolyLine	183	183	6733369	01070001000128	19970521
PolyLine	184	184	6733371	01070001000129	19970521
PolyLine	185	185	6733373	01070001000130	19970521

Incoming Flow (...)

Com_id_1	Com_id_2	Seq#
6733371	6733369	
6733373	6733371	
6734465	6733371	

Outgoing Flow ...

Com_id_1	Com_id_2	Seq#
6733369	6733367	
6733371	6733369	
6733373	6733371	

Node (nhd.node)

Shape	Arc#	Nhd#	Nhd-id	Com_id	Ftype
Point	5	1	1	-9998	
Point	3	2	2	-9998	
Point	1	3	3	-9998	
Point	13	4	4	-9998	

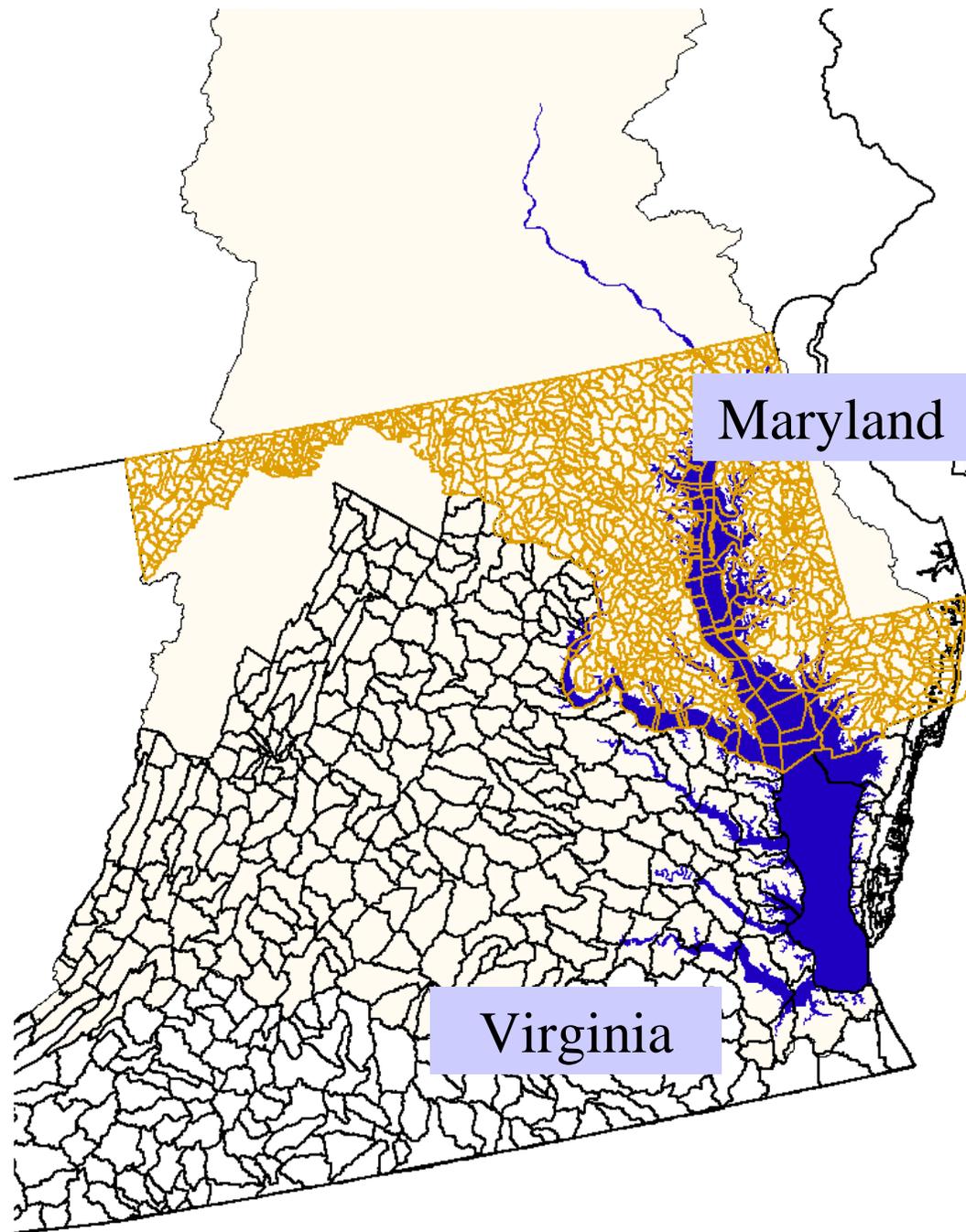
NHD Toolkit

Network Properties

Watersheds

- One watershed for each reach with UNIQUE ID that matches stream reach
- Methods for creating watersheds
 - Delineate & Digitize (takes time)
 - Use Existing Boundaries
 - Density issues in multi-state applications
 - May not contain desired stream-reach
 - May be required by cooperating agency
 - DEM
 - Cooperating agency may have issues
 - Accuracy concerns
 - DEM in conjunction with existing boundaries

Watershed density and scale



Watersheds
stopping at
jurisdictional
boundaries

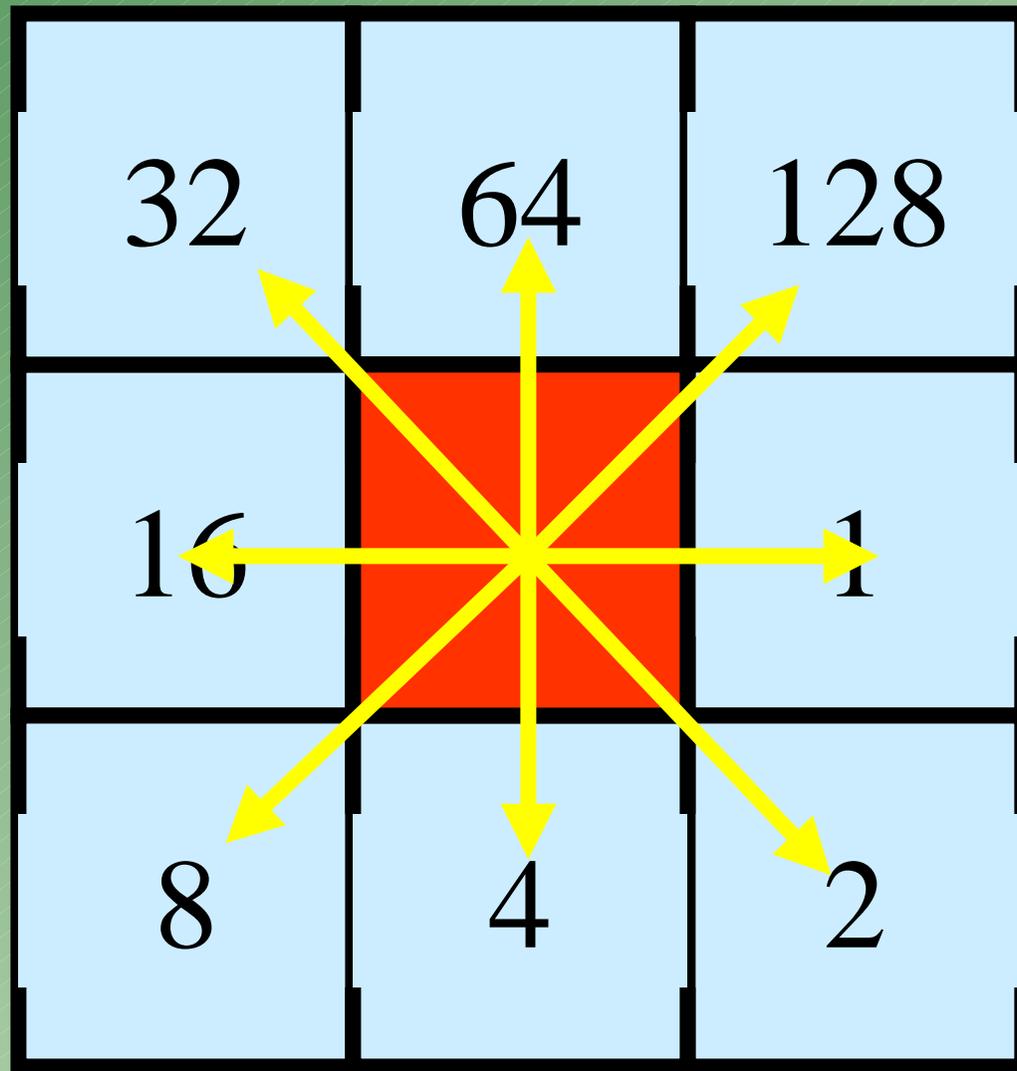


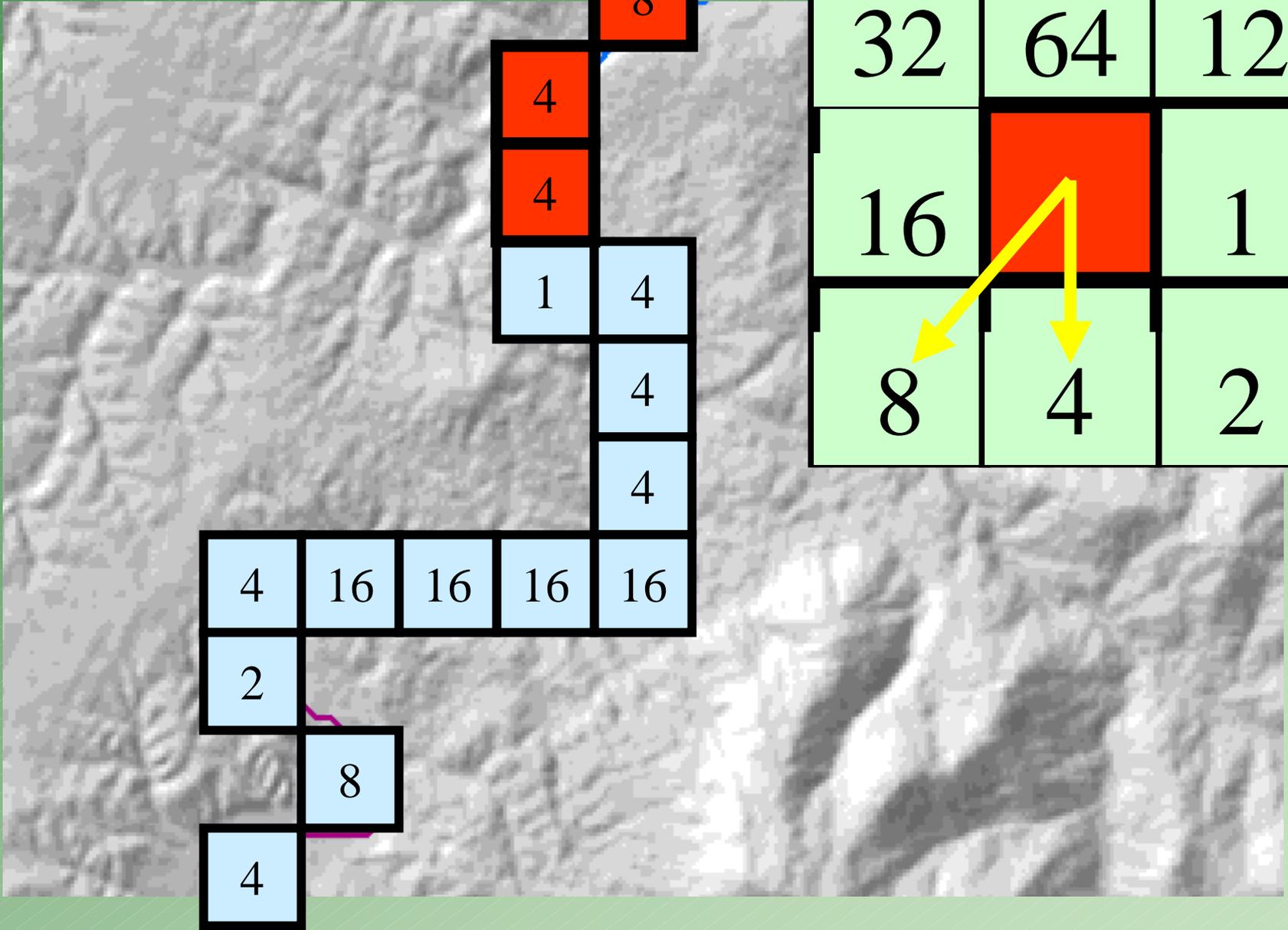
Can
calculate
slope and
direction
of slope

91	90	89	88	90	91	90	95	80	75	75	90	87
90	70	80	90	41	88	55	60	65	75	75	90	87
91	93	95	97	97	87	89	90	91	75	75	90	87
100	99	98	97	95	86	85	91	92	75	75	90	87
95	96	97	95	93	85	83	88	90	75	75	90	87
96	96	97	94	90	88	82	85	87	89	92	90	89
97	96	74	75	77	78	79	86	87	87	90	91	92
88	87	73	78	79	80	80	86	88	89	90	90	90
89	90	84	72	79	81	80	84	88	90	91	92	90
90	88	71	73	80	80	84	85	86	90	93	92	91

DEM Structure

Flow Direction





8

4

4

1

4

4

4

4

16

16

16

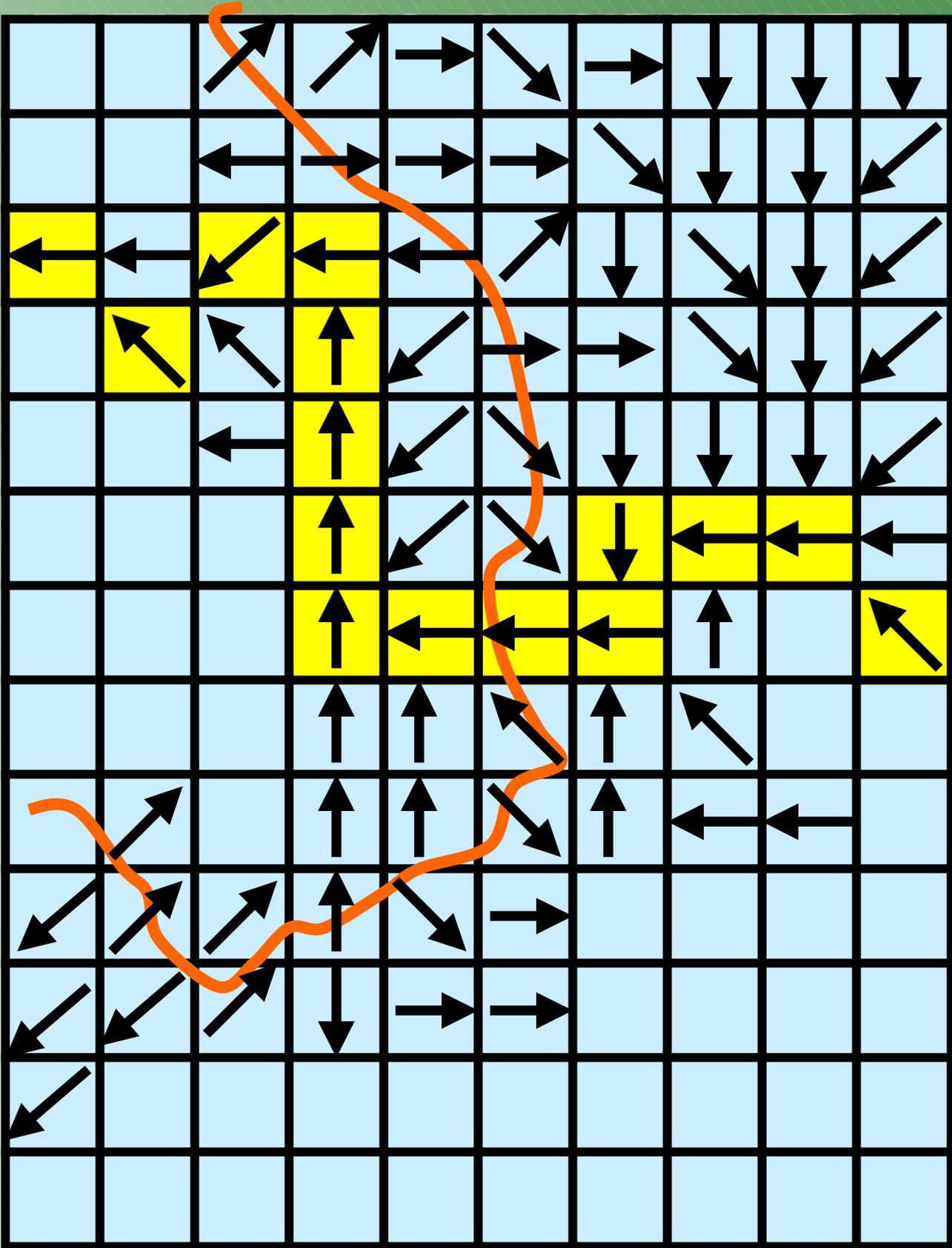
16

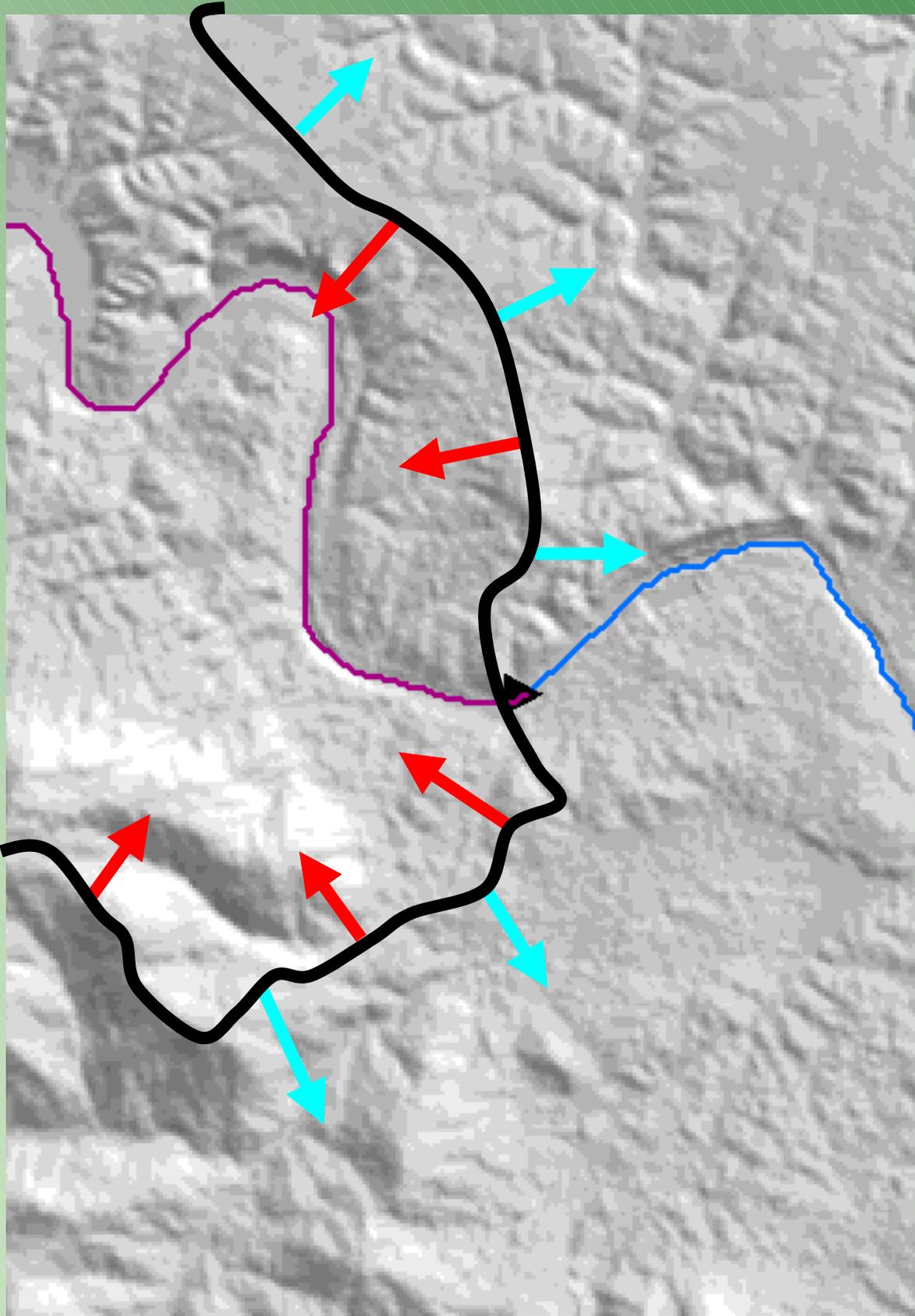
2

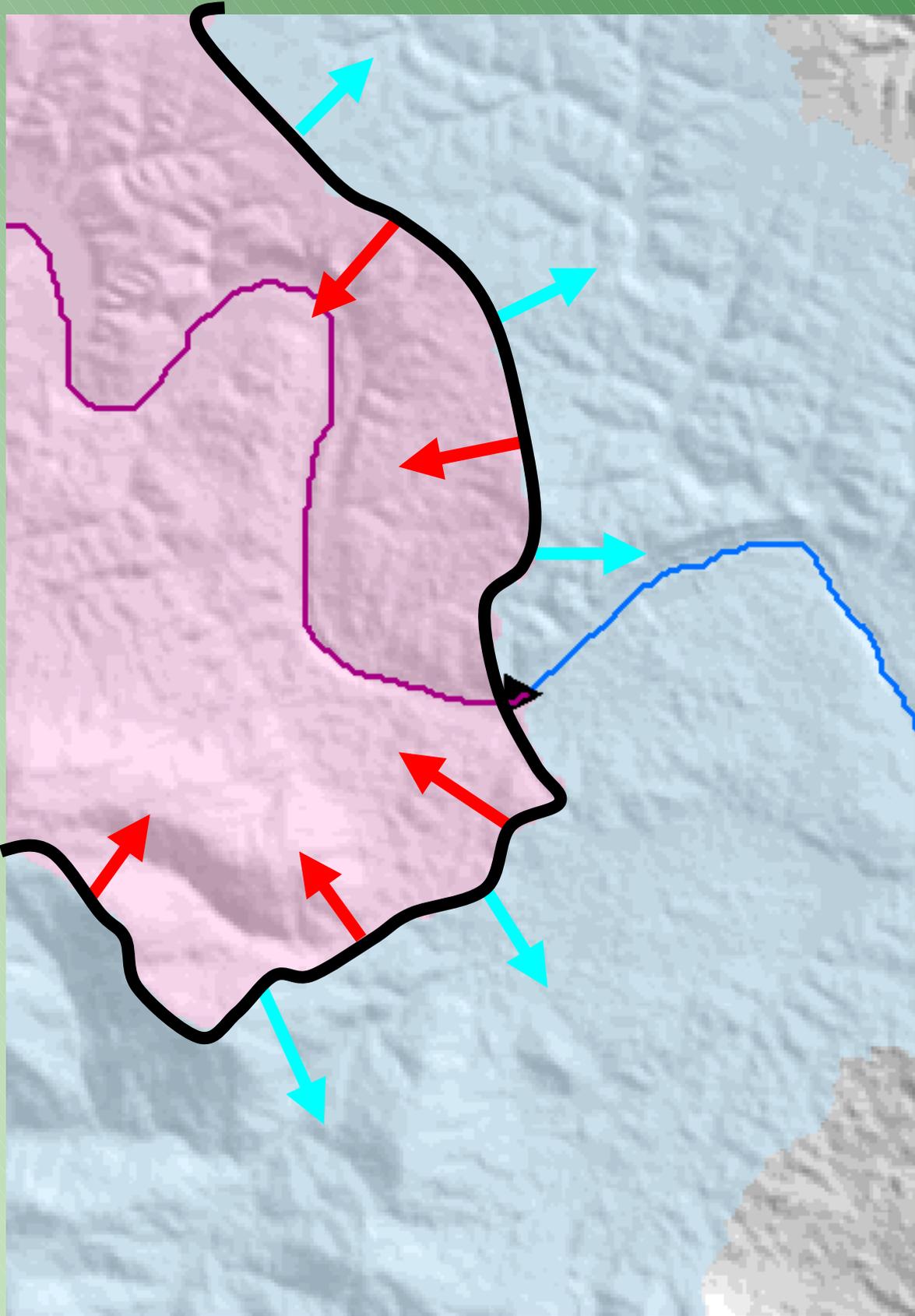
8

4

32	64	12
16		1
8	4	2







Network Construction

Watershed Segments

- Visual comparison of boundaries
- Area comparisons from monitoring stations
- One UNIQUE-ID that matches reach and watershed
 - One reach, one watershed, same ID
 - Can use FREQUENCY to compare watershed and reach ID's

9001
watershed

9001
reach

3092
reach

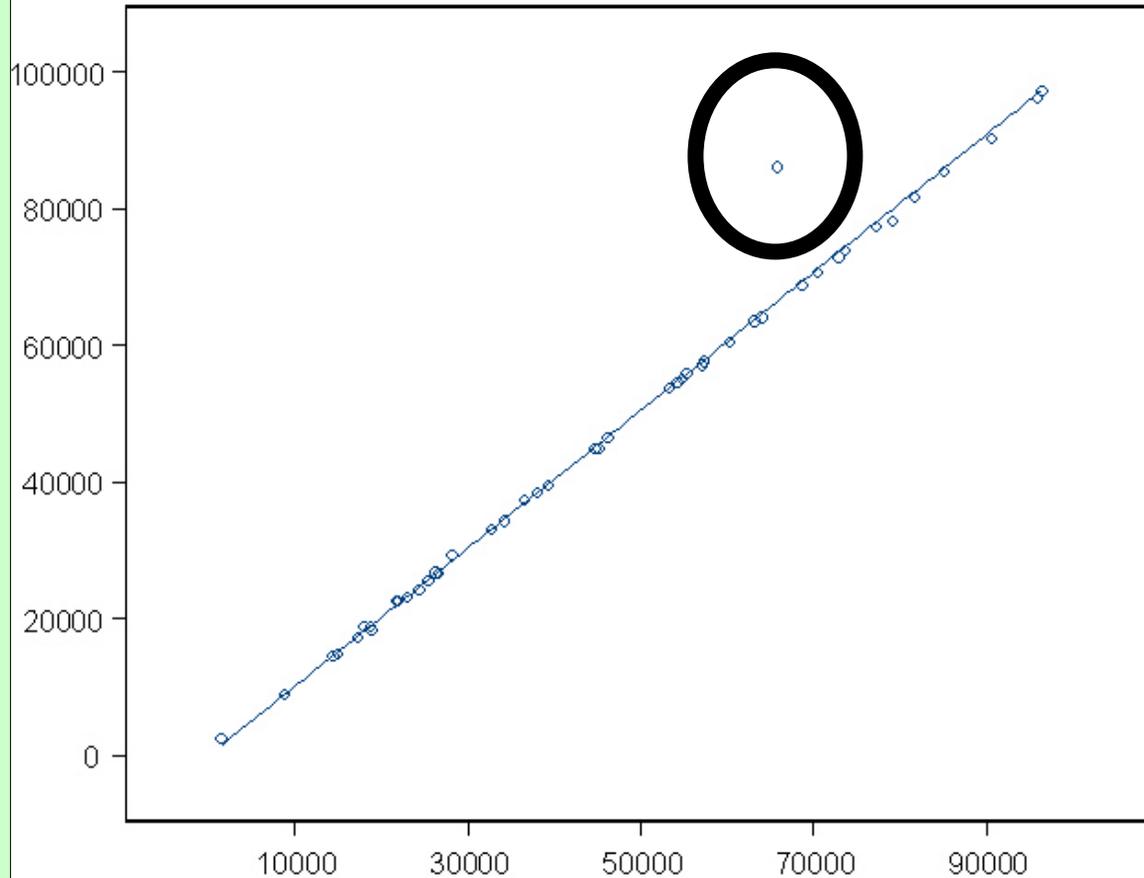
3092
watershed

Watershed Area Comparison

Watershed Area from Monitoring Stations

Identify suspect watershed areas

Published Area in Hectares



1992 Area in Hectares

Network Construction

PRESENTATIONS BY REGIONAL SPARROWS ON DIFFERENT NETWORK GENERATION APPROACHES

- National Applications
- Chesapeake Bay Applications
- New England Applications